ANNUAL REPORT

OF THE

GEOLOGICAL SURVEY

OF

PENNSYLVANIA

FOR

1887.

By the STATE GEOLOGIST.

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1. CAVE FOSSILS, By JOSEPH LEIDY.
2. FOSSIL TRACKS IN THE TRIAS, By A. WANNER.
3. NEW BOSTON BASIN, By B. S. LYMAN.
4. STATE LINE SERPENTINE, By F. D. CHESTER.

WITH 2 LITHOGRAPH PLATES, 11 PAGE PLATES, 5 CUTS IN THE TEXT, AND A TOPOGRAPHICAL MAP IN THE POCKET.

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LETTER OF TRANSMITTAL.

To his Excellency Governor James A. Beaver, *Chairman ex-officio of the Board of Commissioners, of the Geological Survey of Pennsylvania.*

Sir:—I have the honor to present for your approval, the Annual Report for 1887.

The actual work of the Survey during 1887 and 1888 in the anthracite region, has been published in the form of atlases of mine sheets, columnar section sheets and cross-section sheets, as fast as these could be prepared and engraved; and those already published have been distributed throughout the region, and are in constant use at the collieries. The remainder will be published during the summer and autumn of this year, 1889. The Anthracite survey was finished and the corps disbanded on the 31st of May, as ordered by the act of Assembly of 1887.

The work of the survey during 1887 and 1888 in the bituminous coal region, in the gas and oil region, in Juniata, Mifflin, Snyder and Union counties, in the brownstone region of southeastern Pennsylvania, and in the Orwigsburg valley, will all be published during the coming summer and autumn.

The collections of fossils have been restudied, and final catalogues published. The Fossil Dictionary, Vol. 1, has gone through the press, and the printing of Vol. 2 will commence August 1st.

The present volume has been arranged to prevent a break in the series of annual reports. It contains Dr. Leidy's description of the fossil bones found in the Crystal cave in Lehigh county, a short account of the fossil footprints

found by Mr. Wanner in York county, Mr. Lyman's private survey of the Boston Company's Anthracite basin offered as a supplement to the State survey of the region by the owners, and a mineralogical description of the serpentine of Chester county, by Prof. Chester of Delaware College.

I remain, sir, with great respect,

Your obedient servant,

J. P. LESLEY,

Philadelphia, July 1, 1889.

TABLE OF CONTENTS.

Report on the State line serpentine and associated rocks.

By Prof. FREDERICK D. CHESTER.

LIST OF ILLUSTRATIONS.

Notice and description of fossils in caves and crevices of the limestone rocks of Pennsylvania.

By Prof. JOSEPH LEIDY.

Crevices, depressions, and caves of rocks communicating with the outside become receptacles of the debris of the surrounding country. The debris gradually accumulates more or less rapidly or slowly during a long period of time according to the readiness of access and other circumstances. The materials mainly consist of the soil with fragments of rocks of the vicinity together with the remains of plants and animals of the region, which may have fallen or worked in from above or have been conveyed in by various means through lateral openings. Caves of sufficient capacity and ease of access serve as dens for wild beasts and as convenient shelters and habitations of men. The accumulation of material in caves, being less liable to disturbance and the effects of the weather, than when exposed outside, is in a condition favorable to preservation for an indefinite period of time; and the subsequent examination of such accumulations have often led to the discovery of numerous remains of animals, which have given us more information of the character of the early inhabitants of the neighboring country than we have ascertained from other sources. In view of the knowledge thus obtained it is of the utmost importance that whenever such remains are found they should be carefully collected and submitted to those who are qualified to determine their nature and relations. It is especially in the limestone that caves and crevices occur in which animal remains are deposited and it is therefore to be particularly noted that in the quarrying of limestones such accumulations are to be looked for. The writer has reason to believe that important deposits have been overlooked or inadvertently destroyed by those who are not sufficiently informed to suspect their nature and importance. In one in-

stance a miner, near Galena, Illinois, informed a friend of the writer that on an occasion in exploring for lead in the cliff limestone, he had removed from a crevice a large accumulation of bones, which from their conspicuous whiteness were dumped into a separate heap, where they were exposed to the weather, and as might be expected were soon destroyed. In confirmation of the story, at my instigation, the miner procured from the same crevice, about a quart of small bones and fragments, which on examination proved to be those of the extinct peccary, *Platygonus compressus.*

In 1870 in a limestone quarry, near Port Kennedy, Chester Co., Pa., a fissure was exposed which contained the remains of numerous animals and plants of the quaternary period, and these have given us more positive information of the animal life of our country in the age immediately preceding the era of man, than we have derived from all other sources. The remains were submitted to the examination of Prof. E. D. Cope, who has published a preliminary report on them, in the Proceedings of the American Philosophical Society. In this report the author describes and indicates thirty-four species of mammals, with few exceptions extinct, and also several species of birds, of reptiles and of amphibians.

In 1849, Prof. S. F. Baird, in the Proceedings of the American Association for the Advancement of Science, published a notice of his exploration of a cave, on the Susquehanna river, near Carlisle, Pa., in which he discovered a great quantity of bones. He observes that the number of species of mammalia found there is nearly twice that at present existing in Pennsylvania. Nearly five per centum consist of extinct species, the remainder are recent and consist of remains of wolves, foxes, rabbits, beavers, muskrats, otters, lynxes, panthers, bears, etc. Besides these there are numerous remains of birds, particularly of the wild turkey, also of swans, several ducks and other water birds. Of turtles there are eight or nine species; also bones of serpents, an unknown salamander and remains of fishes together with stone arrows and fragments of pottery. It is

greatly to be regretted that we have as yet received no more detailed account of the remains of the Carlisle cave.

In the summer of 1880, Mr. T. Dunkin Paret, of Stroudsburg, Pa., invited the writer, together with Dr. Thomas C. Porter, of Easton, to examine a cave which he had recently explored and had discovered in its contents a quantity of animal remains. The cave, known as Hartman's cave, and later as the Crystal Hill cave, is situated on the south side of a limestone ridge which separates the valleys of the Pocono and McMichael creeks from Cherry valley, about three miles west of Stroudsburg and five miles from the Delaware Water Gap. It occupies the axis of an anticlinal fold of the Helderberg or Upper Silurian limestone, about 800 feet above the level of the Delaware river. The cave had long been known in the vicinity, and was a low passage, extending for about 150 feet into which adventurous boys would creep. Mr. Paret, with the view of ascertaining whether the earthy deposit in the floor of the cave contained anything of interest, commenced the exploration by having a trench dug through an accumulation of debris at the base of the cliff below the mouth of the cave to a sufficient depth to permit a man to enter the cave erect. The excavation was thence extended for upwards of a hundred feet. The floor of the cave is occupied by an accumulation of clay about ten feet in depth and apparently devoid of all organic remains. The clay deposit was covered with a thin layer of stalagmite and on this was about a foot of black friable earth mingled with animal and vegetal remains. This earth was carefully sifted and from it was obtained about a half a bushel of remains mainly of bones and teeth with fragments and a few shells, seeds, and works of art. The collection was submitted to the examination of the writer.

It may not be out of place to inform the reader that the caves of great or small extent which more or less abound in limestone regions have no relation as concerns the time of their formation with the geological age of the rocks in which they are situated. Caves no where appear to be of great antiquity, for all seem to have been excavated in the quaternary age, as water courses, through the agency of

streams from the melting of the ice in the decline of the glacial period. In none of the known caves, whether of this country or of Europe, of South America or Australia, have any remains of animals been discovered other than those which belong to quaternary age. The clay deposits of caves are chiefly the insoluble sediments of the limestone rock through which the streams made their way, as exemplified by the abundant accumulation in the floor of Luray Cave, Virginia, or the deep deposit of Hartman's Cave, or they are partially derived from the outside mingled with the remains of plants and animals also conveyed by the streams from the exterior, as exemplified by the deposits in many of the bone caves of Europe. In the subsequent elevation of the caves above the flow of water commenced the formation of stalactites from the leaky roof and likewise the production of the stalagmitic floor. The deposit of soil on the latter seems to have been due to the accumulation of dusts and the sediments at times of inundation, while the fossils it contains appear to have been chiefly carried into the cave by animals. In the fossils of cave deposits, the remains of animals of the earlier and recent periods, including those of man, are often found more or less commingled and in most cases it is difficult if not impossible to ascertain how far the different species may have been cotemporaneous.

The remains collected in Hartman's Cave chiefly consist of bones and fragments of others, including the rami of mandibles with teeth, and isolated teeth, mostly of the smaller mammals yet living in Pennsylvania or the neighboring States A large proportion of the fragments consist of splinters of long bones of the deer and smaller animals and seem to be the remains of the feasts of small carnivora. Other splinters of large and strong limb bones, probably of the elk, may have been made by our largest carnivora, the wolf, cougar and bear, or perhaps in part are the remnant of human feasts, in which the bones were crushed to obtain the marrow. Most of the bones and fragments exhibit the marks of gnawing, and a few fragments, among which are recognized those of the deer and

elk, are partially charred and are evidently the remains of food prepared by man. With the remains of existing animals are those of a few species which no longer live in Pennsylvania but are found elsewhere in the country, represented by a few jaw fragments and teeth of the woodland reindeer, *Rangifer caribou*, and a lower jaw fragment with the last molar tooth of the bison, *B. americanus*. In association with them there were also found a few remains of several animals now extinct, as instanced by portions of both jaws with teeth of the peccary and teeth of the great extinct beaver, *Castoroides*. In addition with the bones were found a few objects of human art, consisting of implements of bone, etc.

The bones and teeth of still existing animals which have been identified are as follows :

Lynx, *Felis canadensis* Five mandibular rami, etc.

Gray fox, *Vulpes virginianus* Five do, etc.

Wolf, *Canis lupus* Fragments of the mandible, teeth, etc.

Skunk, *Mephitis mephitica*. Nine skulls and crania, 44 mandibular rami, numerous teeth and limb-bones, etc. In one skull the first premolar has two distinct roots.

Weasel, *Putorius ermineus*.

Raccoon, *Procyon lotor*. Two nearly entire skulls, portions of six others, 62 mandibular rami, numerous teeth and limb-bones, 8 penal bones, etc.

Mole, *Scalops aquaticus*

Dusky bat, *Vespertilio fuscus*.

Little brown bat, *V. subulatus*.

Woodchuck *Arctomys monax*. Six parts of skulls, 58 mandibular rami, numerous teeth and limb bones, etc.

Porcupine, *Erethizon dorsatus*. Three parts of skulls; 11 mandibular rami, numerous incisors, bones, etc.

Beaver, *Castor fiber*. Four mandibular rami, a few teeth and limb-bones.

Muskrat, *Fiber zibethicus*. Three mandibular rami, a few incisors and limb-bones.

Gray squirrel, *Sciurus carolinensis*. Seven mandibular rami, 16 incisors, a few limb-bones.

Ground squirrel, *Tamias striatus.* Ten mandibular rami, etc.

Meadow mouse, *Arvicola riparius.* Two mandibular rami, etc.

White-footed mouse, *Hesperomys leucopus.* One mandibular ramus, etc.

Wood rat *Neotoma floridana.* Ninety-two mandibular rami, 13 pairs of upper maxillae, numerous limb-bones, etc., They are generally of comparatively large size and appear to accord with similar remains referred by Prof. Baird to a supposed extinct species with the name of *Neotoma magister.* See U. S. P. R. R. Exp. and Surveys, Zoology, VIII, 1857, 498.

Gray rabbit, *Lepus sylvaticus.* Ten mandibular rami, 3 pair upper maxillae, molar teeth and limb-bones.

Deer, *Cervus virginianus.* Eight mandibular rami, fragments of others and of maxillae, teeth and numerous fragments of limb and other bones.

Elk, *Cervus canadensis.* Fragments of the mandible, a large fragment of an antler with the surface completely gnawed away, fragments of limb-bones, etc.

Among the remains none appear to belong to our domestic animals, unless perhaps it be a pair of teeth of a horse, which were yet incompletely developed. They probably belonged to an indigenous species.

The collection further contains numerous bones of birds, chiefly of the wild turkey, *Meleagris gallopavo;* some of turtles, the box turtle, *Cistudo clausa*, *Emys*, and the snapper, *Chelydra serpentina* and others of several snakes.

Mingled with the bones were a number of snail shells of *Helix albolabris*, *H. alternata* and *H. tridentata.* With them were also a valve of the river mussel *Unio complanatus*, and a pair of valves of the shell of *Margaratina margaritifera*, with the fragment of another. The finding of both valves of the same shell together renders it probable that the mussel was obtained from the Delaware river, where the species is now not found.

Of vegetal remains mingled with the foregoing, besides a few small fragments of charcoal there were many seeds

Figs. 1-6. Bone implements. 7. Conus ternatus. 8. Castor fiber.

consisting of those of the dogwood, *Cornus florida*, the pignut *Carya porcina*, and the walnut, *Juglans nigra*.

The remains of human art found in association with the remains of the animals above indicated are as follow:

A bone fish hook, represented in figure 6, plate I.

It is a little less than an inch and a quarter deep, and has a straight rounded shaft, a sharp, curved-up, unbarbed point, and a groove around the upper extremity. It resembles similar ones from Ohio and Illinois, represented in Rau's "Prehistoric Fishing," p. 127.

A harpoon head made of an antler prong of a deer, represented in fig. 4. The end is pointed, conical, and has a single barb to one side, and the shaft below is half cylindrical, broken at the extremity. The length of the specimen in its present condition is three and a half inches, of which the point from the barb is a little more than two inches.

Five bone awls, manufactured of splinters of the shaft of limb-bones of the deer. They have the sharpened extremity smoothly rounded, conical and pointed, with the other extremity showing the fractured borders. Three of the specimens, represented in figures 1–3, measure respectively about 3, $4\frac{1}{2}$ and $5\frac{1}{4}$ inches. Those of figures 1 and 2 are considerably gnawed. Another specimen has the point gnawed off so as to appear chisel-like. The smallest specimen is $2\frac{3}{4}$ inches long.

A bone needle, represented in fig. 5. It had a smooth circular eyelet, which is gnawed away at one side so that in its present condition the specimen resembles a crochet needle. The head is flattened and rounded. The point and one side of the shaft are gnawed away, and one broad side of the shaft is grooved below the position of the eyelet. In its present state the specimen is $2\frac{1}{4}$ inches in length.

A cone shell bored, through the summit and column, to serve as a bead. The specimen is represented in figure 7, and Mr. George W. Tryon informs me that it is the *Conus ternatus*, a shell which belongs to the west coast of Central America.

A celt or spear-head of brown argillite. It is thin and sharply chipped away to the edges. The base is nearly

straight across. The length is about 8 inches, the breadth a little over 2 inches.

A fragment of a knife of black hornstone.

A fragment of brown baked pottery composed of clay and comminuted shell, with markings of wicker-work on the outside.

The remains of extinct animals discovered in the cave with the preceding are as follows:

Dicotyles pennsylvanicus.

Portions of the upper and lower jaws of a young peccary belong to an extinct species of *Dicotyles* which I shall provisionally distinguish as the *Dicotyles pennsylvanicus*, though I formerly referred it to another extinct species, *Dicotyles nasutus*, founded on the fragment of an upper jaw from Gibson county, Indiana, (Jour. Acad. Nat. Sc. VII, 1869, 385, Pl. XXVIII, Figs. 1, 2) The latter fossil pertains to an adult animal and as it does not correspond with the pieces of the former it is by no means certain that they belong to the same species, though from the narrow proportions of the fore part of the lower jaw of one and of the upper jaw of the other, in comparison with the same parts in all other and better known species, they were suspected to be the same, and such probably may be ultimately proved to be the case on the finding of more complete material.

The lower jaw of *D. pennsylvanicus*, consists of both rami, of which the portions are lost back of the first permanent true molars. On both sides the molar series, consisting of the three temporary molars and the first permanent true molar, are retained and well preserved. The temporary canines still existed but are broken off, and the summits of the permanent canines protrude about 8 millemetres. The temporary incisors, of which there were but two to each lateral series, are lost, excepting the second on one side. The two permanent successors are retained on both sides concealed within the jaw.

The upper jaw fragment consists of that portion which contains on both sides the posterior two temporary molars,

with the alveoli of the first one on one side, and the first permanent true molars of both sides.

The first permanent true molars in both jaws have about the size, form and construction of the second true molars of the *Dicotyles labiatus*, and it is inferred from the size of the premolars in the fossil representing *D. nasutus* that they would accord in size with the same teeth of this species. In comparison with the corresponding teeth of the allied genus *Platygonus* they rather accord with those of *Dicotyles*, that is to say the principal constituent lobes of the crown are less produced and more conical than pyramidal and the secondary lobes are proportionately better produced.

The last upper temporary molar as in the recent peccaries is simply a somewhat diminished representative of the permanent tooth behind it. The last lower temporary molar is also like the corresponding tooth in the recent peccaries, as in them having three pairs of principal constituent lobes to the crown

The second upper temporary molar nearly accords in form and construction with the corresponding tooth of recent peccaries but has the outer portion of its crown proportionately rather better developed. The second lower temporary molar resembles the last one much more than it does in *D. torquatus*, and is a diminished representative of the last one with its anterior portion proportionately less well developed.

The first upper temporary molar is lost in the fossil, but a remaining socket indicates a tooth similar to that in the living peccaries. The first lower temporary molar has its posterior portion much better developed than in *D. torquatus*, with its median portion proportionately less developed and the anterior portion nearly the same, so that it more nearly resembles the succeeding teeth than it does in the latter species.

The lower jaw is less robust and of less depth than in the living peccaries while it is much narrower and more prolonged in advance of the molar teeth, and the canines and incisors are smaller, but the molars equally robust. The

form and proportions of the jaw more nearly accord with those of the allied genus and species *Platygonus compressus*. The symphysial portion of the jaw is proportionally longer and much narrower than in the recent peccaries. In front it is more cylindroid and exhibits more of the flatness presented in the latter, and it forms a nearly uniform slightly convex slope as in the peccaries, and nothing of the obtuse angle seen in *Platygonus*.

The length of the hiatus in advance of the molars and extending to the canines is much greater than in the recent peccaries, is a little greater than in *Platygonus compressus*, and is almost the same as in the upper jaw fragment of *Dicotyles nasutus*. The hiatus is defined by an acute edge sweeping in a concavity from the molars to the canines. Below the hiatus, in advance of the middle on one side, there is a row of three vaso-neural foramina, and on the other side two foramina. Below the incisors in front there is also a foramen on each side, and at the bottom of the symphysis internally there exists another pair of foramina.

The number of incisors in *D. pennsylvanicus*, in both the temporary and permanent set of the lower jaw, appears to have been only two on each side, therefore one less than in the recent peccaries, and the same number as in *Platygonus compressus* in the mature state. Between the lateral incisor and the canine there is a hiatus of eight millemetres, which shows no trace of an alveolus. The same position in the recent peccaries is occupied by an incisor; and in a young skull of *Platygonus compressus* there exists a shallow alveolus of a small incisor, though no tooth of the permanent series occupies this position in adult skulls. Of the permanent incisors, enclosed within the jaw, and partially visible through imperfection of the alveoli, the first appears nearly twice as large as the second. Its crown is vertically oval compressed fore and aft and has the upper border divided into two tubercles. The crown of the second incisor has the same form but is undivided at the summit. A remaining second temporary incisor has nearly the same form as the latter, but is smaller.

The upper jaw fragment would appear to have nearly the same size and proportions as they may be supposed to be in *D. nasutus*, and the palate between the position of the molar series in nearly corresponding positions exhibits similar longitudinal vaso-neural grooves, but none of the transversely ridged appearance observed in *D. labiatus*. In *D. nasutus* and also in *D. torquatus*, the alveolar border of the jaw, above the premolars, in advance of the infra-orbital canal, forms a conspicuous outwardly projecting ridge which is not the case in *D. pennsylvanicus*. In this the infra-orbital canal appears to have opened above the middle of the second temporary molar; but in *D. nasutus* it opened back of the latter, but to what distance cannot be determined by its characteristic fossil. The width of the palate between and just in advance of the molar series appears to have been nearly the same as in the latter.

Comparative measurements are as follows:

	D. pennsylvanicus.	D. labiatus.	D. torquatus.	Platygonus compressus.
LOWER JAW.				
Distance from back of first permanent molar to front of incisive alveoli,	144 mm	109	95	124
Length of symphysis in front,	70	66	52	80
Depth of jaw below first permanent true molar,	30	40	30	36
Thickness of jaw below first permanent true molar,	18	17	12	15
Width of jaw below first permanent true molar,	57	66	49	70
Narrow part back of canines,	20	32	28	28
Width between edges of hiatus on each side,	14	22	16	16
Length of hiatus in advance of molars,	62	30	25	53
Width of jaw at canine alveoli,	26	35	30	36
Width at incisive alveoli,	18	29	25	19
Length of temporary molar series,	38	...	28	31
Fore and aft diameter first permanent true molar,	16	14	13	14
Transverse diameter first permanent true molar,	13	12	10	10
Fore and aft diameter last temporary molar,	18	...	15	....
Transverse diameter last temporary molar,	10.5	...	9	....

	D. pennsylvanicus.	D. labiatus.	D. torquatus.	Platygonus compressus.
Lower Jaw.				
Fore and aft diameter second temporary molar, ...	11	. . .	8	. . . .
Transverse diameter second temporary molar, ...	7	. . .	4	. . . .
Fore and aft diameter first temporary molar, ...	7	. . .	6	. . . .
Transverse diameter first temporary molar,	4.5	. . .	3	. . . .
Length of crown of first incisor, ...	10	. . .	. . .	. . . .
Breadth of crown of first incisor, ...	5	. . .	. . .	. . . .
Upper Jaw.				
Breadth at first permanent true molars, . .	48	54	40	47
Breadth at first temporary molars, ...	40	. . .	31	35
Width of palate between first permanent true molars, ...	19	25	19	23
Width of palate between first temporary molars, ...	22	. . .	20	22
Length of temporary molar series, ...	38	. . .	28	31
Fore and aft diameter first permanent true molar, ...	16	14	. . .	14
Transverse diameter first permanent true molar, ...	14	14	. . .	12
Fore and aft diameter third temporary molar, ...	14	. . .	. . .	12
Transverse diameter third temporary molar, ...	12	. . .	. . .	11
Fore and aft diameter second temporary molar, ...	13	. . .	. . .	11
Transverse diameter second temporary molar, ...	10	. . .	. . .	10

As related with the peccary of Hartman's Cave, I give the description of the remains of another species from a limestone quarry of Mifflin Co., Pa.

Platygonus vetus.

Fragments of jaws with teeth of a large species of peccary, referrable to the genus *Platygonus*, I have previously described under the name of *Platygonus vetus* (Proc. Acad. Nat. Sci. 1883, 301). The specimens, thickly encrusted with a ferruginous cement of limestone and gravel, were obtained from a crevice in a limestone quarry in Mifflin Co.,

Pa., and were presented to the Academy of Natural Sciences by Mr. John Swartzer through Dr. W. B. Henderson.

The specimens, together with the teeth, so closely accord in size and anatomical characters with the corresponding parts of more complete ones, recently discovered in Guanajuato, Mexico, and described by Dr. Alfredo Duges, under the name of *Platygonus alemanii*, (Naturaleza 1887, 16), that I suspect them to be the same.

The upper jaw fragment, fig. 1, plate II, consists of the molar part of the maxillæ containing on one side the true molars and on the other side the anterior two true molars and the last premolar. The teeth are all highly characteristic of the genus, compared with those of *Dicotyles* from which they are distinguished by the more prominent development of the constituent lobes of the crown, which give them a greater resemblance to the corresponding elements in the teeth of ruminants than in the latter. The crown of the last premolar is transversely oval at base and exhibits a single pair of prominent pyramidal lobes, with a basal ridge fore and aft, but no accessory lobes behind such as exist in *Dicotyles*. In the last molar the fifth lobe of the crown is better developed than in the latter.

The lower jaw fragment consists of that portion of the left ramus which contains the last two molars and extends to the base with the forepart of the prominent angle. The bone has nearly the size and form of the corresponding part of *Platygonus alemanii*. The specimen contains the last molar tooth, fig. 2, deprived of the antero-external lobe of its crown, and the base of the preceding molar retaining only the postero-external lobe of the crown. These teeth equally with the upper ones are quite characteristic of *Platygonus*.

Comparative measurements of the specimens are as follows: Those from *P. alemanii*, are from what I take to be the original specimen of the lower jaw described by Dr. Duges, and subsequently presented to the Smithsonian Institution, in the name of which it was submitted to me for examination by Prof. Baird.

	P. vetus.	P. alemanii.	P. compressus.
Upper Jaw.			
Space occupied by the last two premolars and the true molars, ...	85 mm	80*	65
Space occupied by the true molars, ...	60	52*	46
Fore and aft diameter last true molar, ...	25.5	22*	20
Transverse diameter last true molar, ...	18.5	15*	13
Fore and aft diameter second molar, ...	20	20*	16
Transverse diameter second molar, ...	18	15*	15
Fore and aft diameter first molar, ...	17	15*	13
Transverse diameter first molar, ...	15.5	13*	12
Fore and aft diameter last premolar, ...	12	10*	10
Transverse diameter last premolar, ...	15	12*	12.5
Width of palate between second true molars, . . .	26	18*	22
Lower Jaw.			
Depth below second true molar, ...	42	46	37
Thickness below second true molar, ...	25	22	17
Depth from back of last molar to bottom of angle,	76	76	60
Fore and aft diameter last molar, ...	26.5	25	22
Transverse diameter last molar, ...	17	14.5	12
Fore and aft diameter second molar, ...	20	18.5	16
Transverse diameter second molar, ...	15	14	12

The measurements of *P. alemanii*, from the upper jaw marked with an * were taken from Dr. Duges' figures (Naturaleza pl. I.) and are probably not exact.

Castoroides ohioensis

Under this name is distinguished, an extinct gnawing animal, 'a cotemporary of the mastodon, allied to the beaver, but of comparatively gigantic size, as will be better appreciated by the reader by comparing its incisors, represented in figures 7, 10, plate II, with the corresponding tooth of the beaver, represented in fig. 21.

This remarkable animal was first made known to us by Mr. J. W. Foster, from remains discovered in association with those of the mastodon and elephant in Ohio (Am. Jour. Sc. 1837, 80; Report on the Geological Survey of Ohio, 1838, 81). Subsequently Prof. J. Wyman described a nearly complete skull, including the mandible, from Wayne county, New York (Boston Jour. Nat. Hist. 1847, 385, pls. 37-39). Another nearly complete skull, from

Coles county, Illinois, was submitted to the examination of the writer. Other remains of the same animal have been found in Illinois, Tennessee, South Carolina, Louisana and Mississippi.

The remains of *Castoroides*, of Hartman's Cave, consist of a nearly complete lower incisor tooth, a fragment of an upper incisor and seven molar teeth.

The lower incisor, fig. 7, fractured in several places, and with little more than an inch of its posterior extremity lost, in the present state, measures along its anterior curvature 8¾ inches. It is trilaterally prismatic with rounded borders, and is slightly twisted on its axis so that the anterior half curves straight forward and upward while the posterior part turns somewhat outward in its course backward. The anterior surface is directed forward and outward, forms a continuous convexity from the inner to the posterior border, and is strongly fluted. The inner surface is a smooth vertical plane, with the posterior border convex and the anterior border more narrowly defined. In the greater part of its length it forms a shallow groove, but at the anterior extremity, for about three inches, is flat, and has the appearance of being worn by friction against the tooth of the opposite side. The posterior surface is grooved along the middle and is convex along its inner and outer borders. The tooth slightly tapers in advance, and the end for about an inch and a half forms a pointed pyramid, fig. 8, with the posterior surface worn off in a slope, with the inner surface flat, and with the antero-external surface convex. The enamel invests the anterior and external fluted surface of the tooth and ceases immediately around the anterior border of the inner surface and at the outer border of the posterior surface. The ridges separating the flutes are convex and mostly extend the length of the tooth, though a few, as they advance, run into contiguous ones.

Of the three surfaces of the lower incisors the outer ones have a different direction from those of the beaver, the fluted enameled surface looking forward and outward while in the latter the smooth enameled surface is directed for-

ward, and while the other surface is directed backward in *Castoroides*, it is directed obliquely outward and backward in the beaver.

The upper incisor tooth of *Castoroides* is a demi-elliptical column rather than a prism as in the lower incisor. The inner surface forms a smooth vertical plane, while the anterior, external and posterior surfaces are convex and together form a half ellipse. The shape conforms more nearly to that of the beaver than in the case of the lower incisor.

In the fragment of the upper incisor, about two inches, from Hartman's Cave, the fluted, enameled surface accords in character with that of the lower incisor. The enamel invests the anterior and outer surface of the crown ceasing on the anterior border of the inner surface and on the outer border of the posterior surface. The flutes are wider at the inner fore part of the tooth than elsewhere. The inner and posterior surfaces are slightly depressed along the middle.

Figure 10, plate II, represents the anterior extremity of an upper incisor of *Castoroides* taken from the excavation of a well at the depth of 40 feet, near Shawneetown, Illinois. It conforms to the fragment above described but indicates a rather more robust tooth, and it has the enameled surface more numerously fluted. The extremity, fig. 11, forms a transverse cutting edge, from which a worn surface slopes away behind for nearly an inch and a half, while the inner part of the surface is worn into a deep recess by the pointed extremity of the lower incisor.

Measurements of the specimens are as follows:

Inferior incisor:		
Fore and aft diameter internally at the posterior third		20 mm
Transverse diameter behind, ...		18.5 "
Length of worn extremity, ...		36 "
Fore and aft diameter at base of latter, ...		16 "
Transverse diameter at base of latter, ...		12 "
Superior incisors.	Fragment	Illinois Specimen.
Transverse diameter, ...	23.5	33 mm
Fore and aft diameter internally, .	19	21 "
Length of worn extremity, ...		36 "

The number of molars of *Castoroides* is the same as in the beaver, but they are very unlike them, and most resemble, both in form and construction, particularly the last lower molar tooth of the capybara, which is composed of a series of narrow, elliptical enamelled columns with the intervals occupied by plates of cementum. In the other molars of this animal, excepting the greater portion of the upper last one, the enamelled columns are divided or have a double fold on the inner side of the lower teeth and the outer side of the upper ones, which gives them a trilateral form. In *Castoroides* the molars, figs. 13–20, are uniformly constructed on the same plan, and except the first of the lower and the last of the upper series, each consists of three enamelled elliptical columns, which are arranged in such a manner that on the triturating surface they appear in the relationship of the letter S. The anterior and posterior columns are transversely oblique, while the intermediate column more oblique joins the others by its extremities at their opposite borders. The first lower and the last upper molars have an additional elliptical and smaller column.

Measurements of the molar teeth are as follows; (with those of the lower teeth others are given for comparison from the specimen of a ramus of the mandible from near Memphis, Tennessee; with those of the upper teeth, others from two molars from near Shawneetown, Illinois).

Lower Molars.	Penn.	Tenn.
Fore and aft diameter, first tooth,	18 mm	19 mm
Transverse diameter of anterior column,	7	8
Diameter across the third column,	18	31?
Transverse diameter of posterior column,	15	17
Fore and aft diameter, second tooth.	15	17
Transverse diameter of anterior column,	12	15
Transverse diameter of middle column,	14	21
Transverse diameter of posterior column,	13	16
Fore and aft diameter, third tooth,	14.5	16.5
Transverse diameter of anterior column,	12.5	14
Transverse diameter of middle column,	16.5	19
Transverse diameter of posterior column,	14	14.5
Fore and aft diameter, fourth tooth,	16	15
Transverse diameter of anterior column,	14	14
Transverse diameter of middle column,	17	16
Transverse diameter of posterior column,	13	14
Upper Molars.		Illinois.
Fore and aft diameter, first molar,	15	. . . . .
Transverse diameter anterior column,	14	. . . . .
Transverse diameter middle column,	17	. . . . .
Transverse diameter posterior column,	16.5	. . . . .
Fore and aft diameter, second molar,	16	11
Transverse diameter anterior column,	15	14.5
Transverse diameter middle column,	16	15
Transverse diameter posterior column,	13	11
Fore and aft diameter, third molar,	. . . . .	12
Transverse diameter anterior column,	. . . . .	13
Transverse diameter middle column,	. . . . .	13
Transverse diameter posterior column,	. . . .	11

Fossil remains from Durham Cave.

The museum of the Academy of Natural Sciences of Philadelphia, contains a small collection of bones, which were obtained from Durham Cave, near Riegelsville, Berks county, Pa., on the Delaware river, presented about forty years ago, but of which I can find no record. They consist of the following remains :

Black bear, *Ursus americanus.*
Raccoon, *Procyon lotor.*
Gray fox. *Vulpes virginanus.*
Skunk, *Mephitis mephitica.*
Woodchuck, *Arctomys monax.*
Porcupine, *Erethizon dorsatus.*
Beaver, *Castor fiber.*

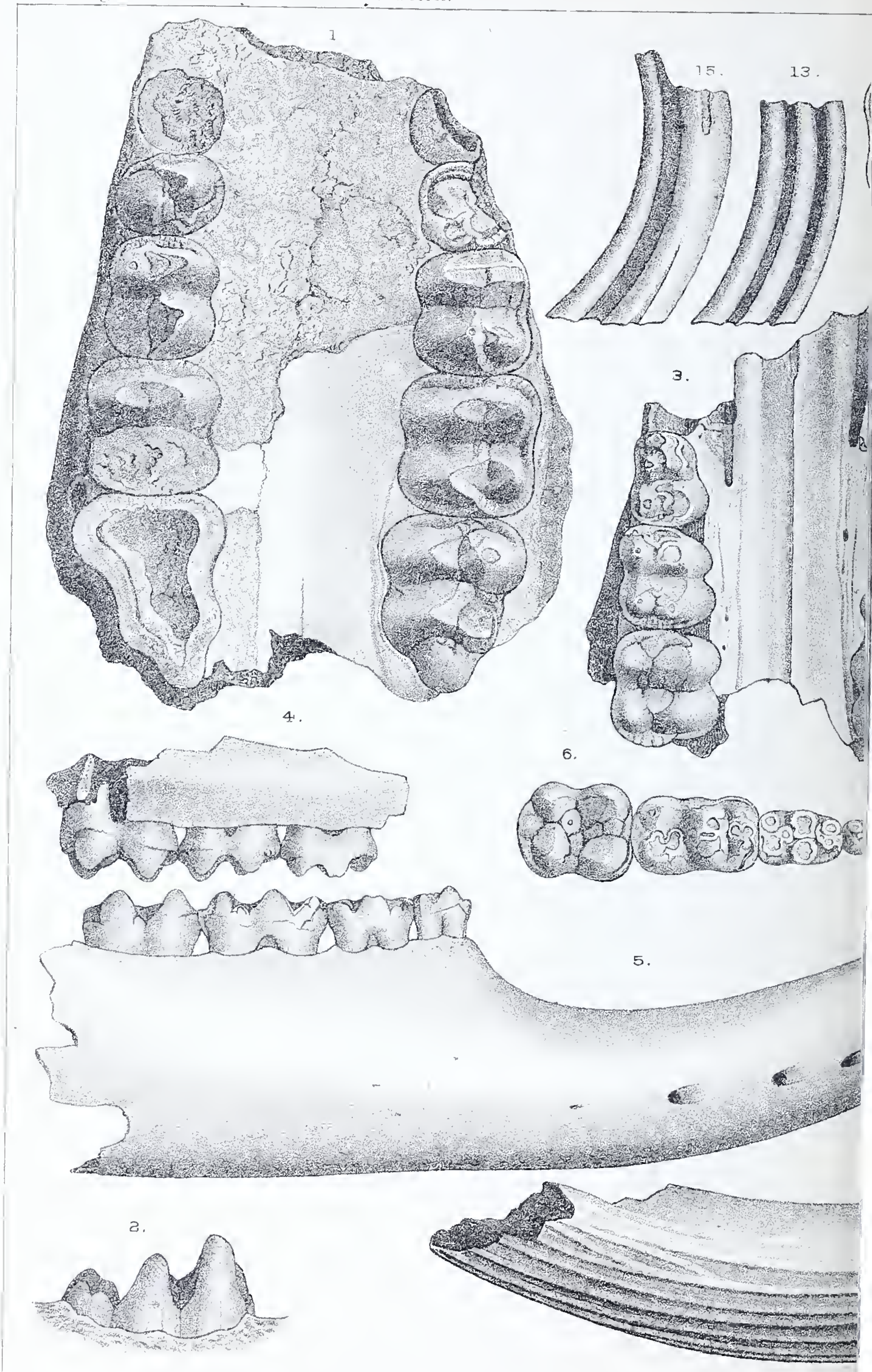
Muskrat, *Fiber zibethicus.*
Gray squirrel, *Sciurus carolinensis.*
Wood rat, *Neotoma floridana.*
Gray rabbit, *Lepus sylvaticus.*
Deer, *Cervus virginianus.*
Elk, *Cervus canadensis.*
Moose, *Alce americanus.*
Wild turkey, *Meleagris gallopavo.*
Box turtle, *Cistudo clausa,*
Snapper, *Chelydra serpentina.*
Snake, *Eutaenia sirtalis.*
Sturgeon, *Acipenser sturio.*
Cat-fish, *Amiurus atrarius.*

Description of the plates.

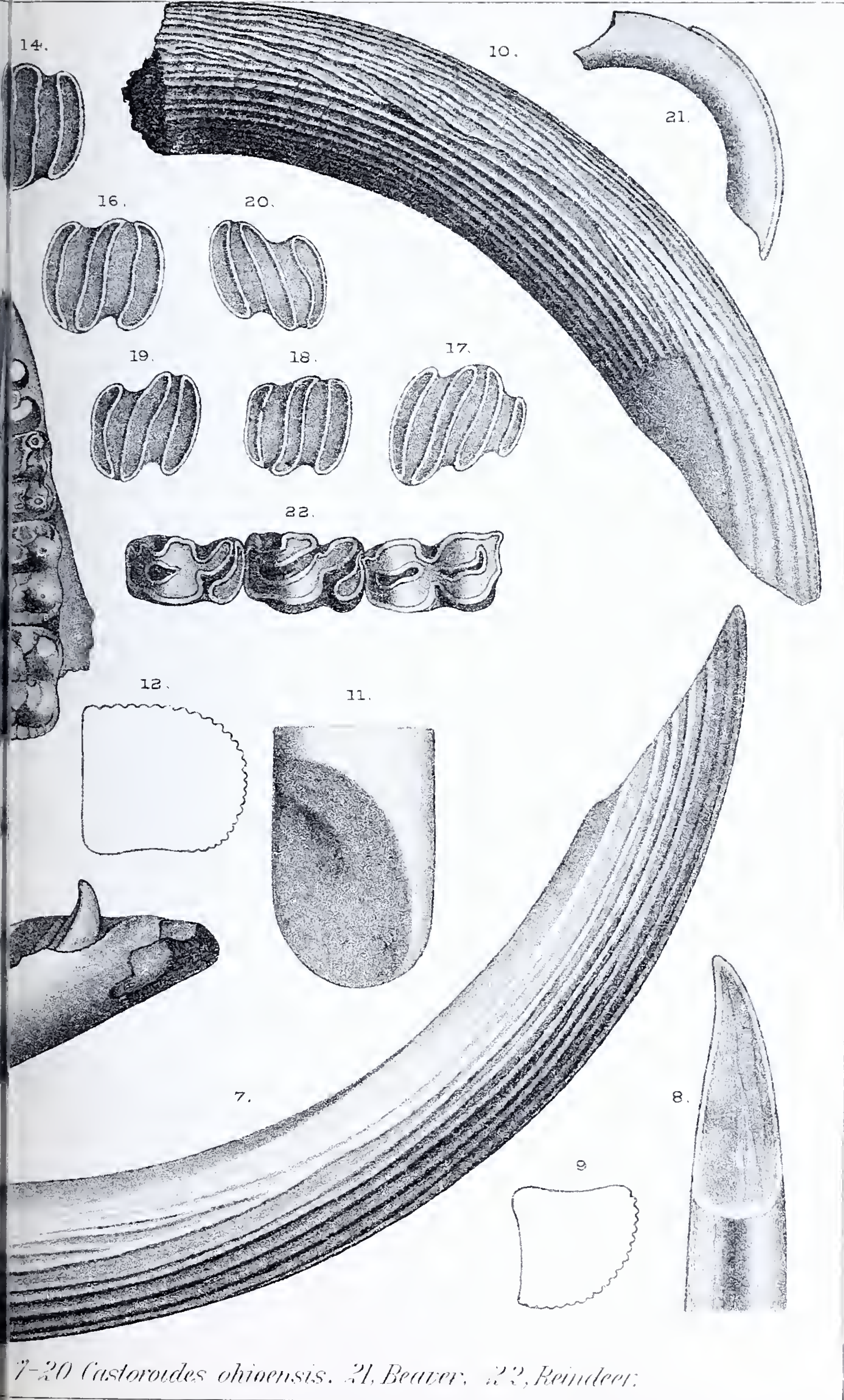
Plate I. Fig. 1. Bone awl, gnawed at the base.
Fig. 2. Bone awl, much gnawed.
Fig. 3. Bone awl, slightly fluted towards the point.
Fig. 4. Harpoon-point made from the prong of an antler.
Fig. 5. Portion of a bone needle, gnawed away on one side.
Fig. 6. Bone fish-hook.
Fig. 7. A cone-shell, *Conus ternatus*, bored through the top.
Fig. 8. Left ramus of the mandible of a beaver.

Plate II. Fig. 1. Portion of the upper jaw of an extinct peccary, *Platygonus vetus*, from Mifflin county, Pa. Specimen encrusted with limestone and exhibiting the triturating surfaces of the molar teeth.
Fig. 2. Inner view of the last molar tooth of the left side, contained in a fragment of the lower jaw.
Figs. 3-6. Remains of a young peccary, *Dicotyles pennsylvanicus*, from Crystal Hill Cave, Monroe county, Pa.
Fig. 3 Portion of the upper jaw, containing the last two temporary and the first permanent molars, viewed on their triturating surfaces.
Fig. 4. Side view on the right of the same specimen.
Fig. 5. Right ramus of the mandible with the temporary molars and first permanent molar.
Fig. 6. View of the triturating surfaces of the same tooth.
Figs. 7-20. Remains of the extinct giant beaver, *Castoroides ohioensis*
Fig. 7. The right lower incisor tooth, from Crystal Hill Cave.
Fig. 8. Posterior view of the worn point.
Fig. 9. Transverse section of the tooth.
Fig. 10. Portion of the upper right incisor tooth, from Illinois.
Fig. 11. Posterior view of the worn end of the same.
Fig. 12. Transverse section of the tooth.
Figs. 13-20. Molar teeth, from Crystal Hill Cave.
Fig. 13. First right upper molar, outer view.

Fig. 14. Triturating surface.
Fig. 15. Second right upper molar, outer view.
Fig. 16. Triturating surface.
Fig. 17. First lower left molar, triturating surface.
Fig. 18. Second lower left molar, triturating surface.
Fig. 19. Third lower left molar, triturating surface.
Fig. 20. Fourth lower right molar, triturating surface.
Fig. 21. Upper right incisor of the beaver.
Fig. 22. Triturating surfaces of the last two lower premolars and first molar, from a fragment of the left mandible of the barren-ground reindeer.



Figs. 1, 2. Platygonus vetus 3-6 Dicotyles pennsylvanicu[s]



7-20 Castoroides ohioensis. 21, Beaver. 22, Reindeer.

The Discovery of fossil tracks, algæ, etc., in the Triassic of York county, Pennsylvania.

BY ATREUS WANNER,
Principal of York High School, York, Penn'a.

[A verbal abstract of this paper was presented to the American Association for the Advancement of Science (Section of Geology and Geography), at the Thirty-seventh meeting, Cleveland, Ohio, 1888.]

The writer announces that he has recently had the good fortune to discover fossil tracks, as well as other fossil forms, in the Triassic of York county, Pennsylvania.

The discovery resulted largely from a belief that a careful investigation of the numerous exposures of "New Red Sandstone" in our county would reveal the presence of fossil tracks, such as have been found in the same formation elsewhere in our State, at Easton and Phœnixville.

Although for years a diligent search was made, whereever there happened to be an exposure, yet it was not until last summer that any discovery was made. At that time a recently opened quarry*, not far from Goldsboro, brought to light fossil-bearing strata.

In the descriptions that follow I shall endeavor to convey a sufficiently definite idea of the specimens found, to enable those who have examined the fossils of the "New Red Sandstone" elsewhere, to determine the value of the discovery.

The fossil-bearing quarry is located in the "New Red Sandstone" in the hillside, about one mile south of Goldsboro. It was opened for the purpose of getting out slabs for paving, chimney caps, etc. The strata, in successive conformable layers, have a N. W. dip of about 40°. They are of nearly uniform thickness, increasing slightly with the depth.

The illustration, Plate 3, represents the quarry as it is now, August, 1888.

The surfaces of slabs 3, 2 and 1 are covered with fossil algæ, No. 3 somewhat more plentifully than either 1 or 2.

*F. T. Scott & Sons'.

PL. 3.

The illustrations, on Plate 4, figs. 1, 2 and 3, representing three small areas of different stones, are intended to show the character and closeness of these impressions.

There seem to be at least two well-defined fossils, the one a delicate, cylindrical branch, having a smooth, or nearly smooth surface, the other much stouter, longer and more prominently marked with short curved striae.

All three slabs are, moreover, covered with elliptical depressions. Fully one-fourth of these depressions conform to the shapes illustrated on Plate 5 and are strikingly suggestive of oyster shells. Fig. 1 is from slab 3; figs. 2 and 3 are from slab 2; figs. 4 and 5 from slab 1. They were purposely selected from the three horizons to show similarity of form and size. I think they are impressions of shells. Slab No. 1, in addition to the fossils described, bears on one part of its surface four, indistinct three-toed tracks. No other exposed slabs in the quarry contain tracks.

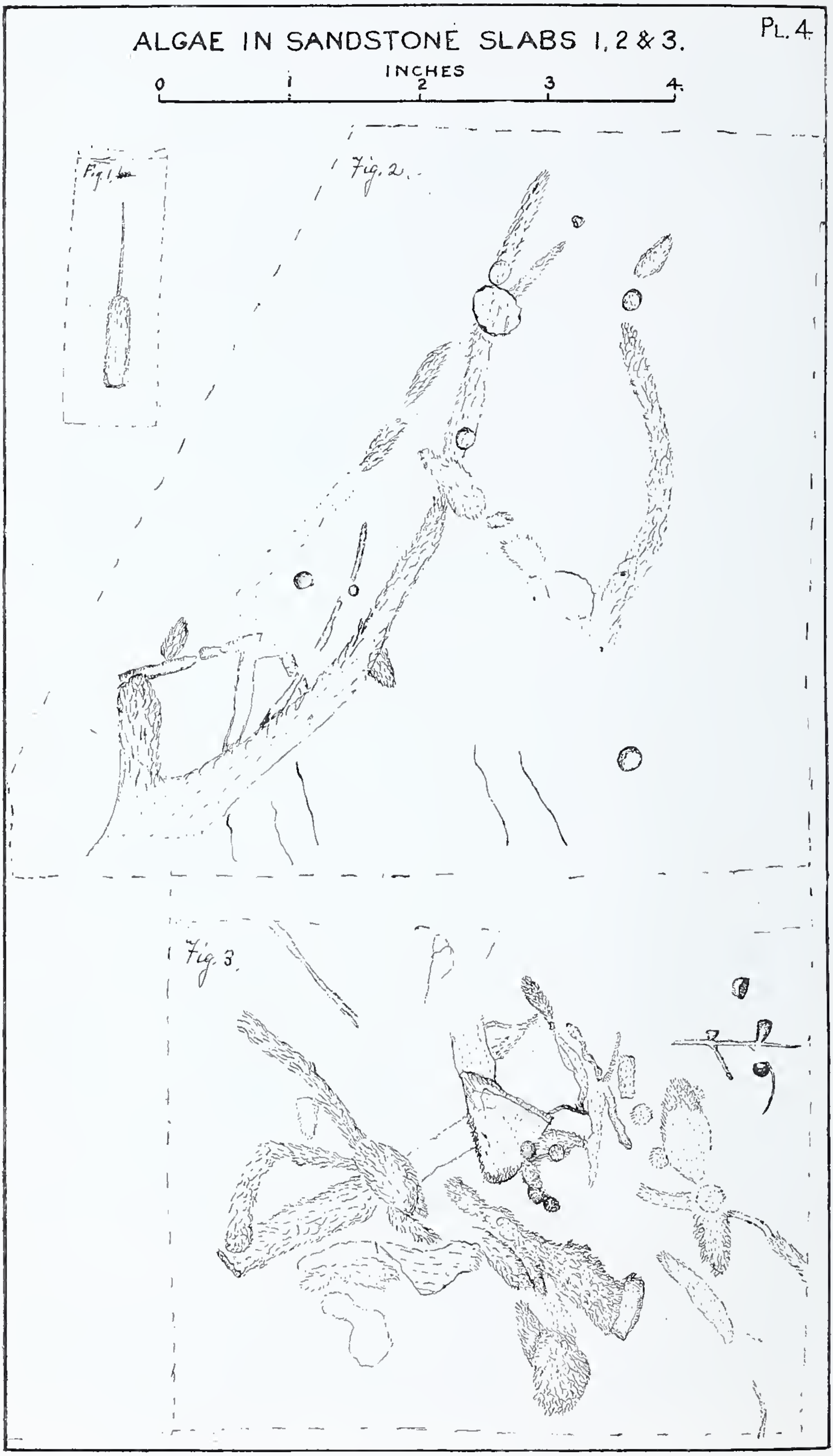
These three horizons, so much alike as to fossil remains, are separated from each other by intervening strata of non-fossiliferous sandstone. From the lowest of the three horizons to the next above bearing similar fossils, is 25 inches; from the middle to the upper horizon, 12 inches.

Thus we have, in sight, within a shallow quarry, no less than three horizons, making three separate formations during which like conditions prevailed.

The following are descriptions of slabs that were found in the order in which they are lettered. Unfortunately I did not see them in situ, in the quarry. When I observed them they had already been detached, nor could I discover to which of the partially exposed horizons they belonged.

Slab lettered A, Plate 10, is now in the possession of the Smithsonian Institution. It contains, in addition to the tracks represented, other impressions that are so indistinct as to be difficult to trace.

Figs. 1, 2, 3 and 4, as also figs. 9, 10 and 11, evidently show the strides of the three-toed animals that produced them. The other tracks cannot be so easily associated, possibly a


ALGAE IN SANDSTONE SLABS 1, 2 & 3.
PL. 4.
INCHES
0
1
2
3
4
Fig. 1
Fig. 2.
Fig. 3.

more careful examination of the stone might result in the discovery of other related impressions.

For some unknown reason nearly all of the tracks lead in the same direction.

Owing to the fragmentary character of No. 16 no conclusions can be drawn as to the form of the body which produced it, yet a number of scale like impressions, in quincunx order, betray its organic origin.

Slabs lettered B and C. Plates 11 and 12, contain a number of impressions, but they are somewhat indistinct. In several instances the overlapping of tracks renders it difficult to decipher them.

The middle part of slab C contains a belt of numerous faint impressions, evidently a sort of path. A few of these impressions, included within the area numbered 6, on Plate 11, are given.

Figs. 8 and 7, on slab C, may be related, at any rate both, besides looking alike, sink deeply into the stone.

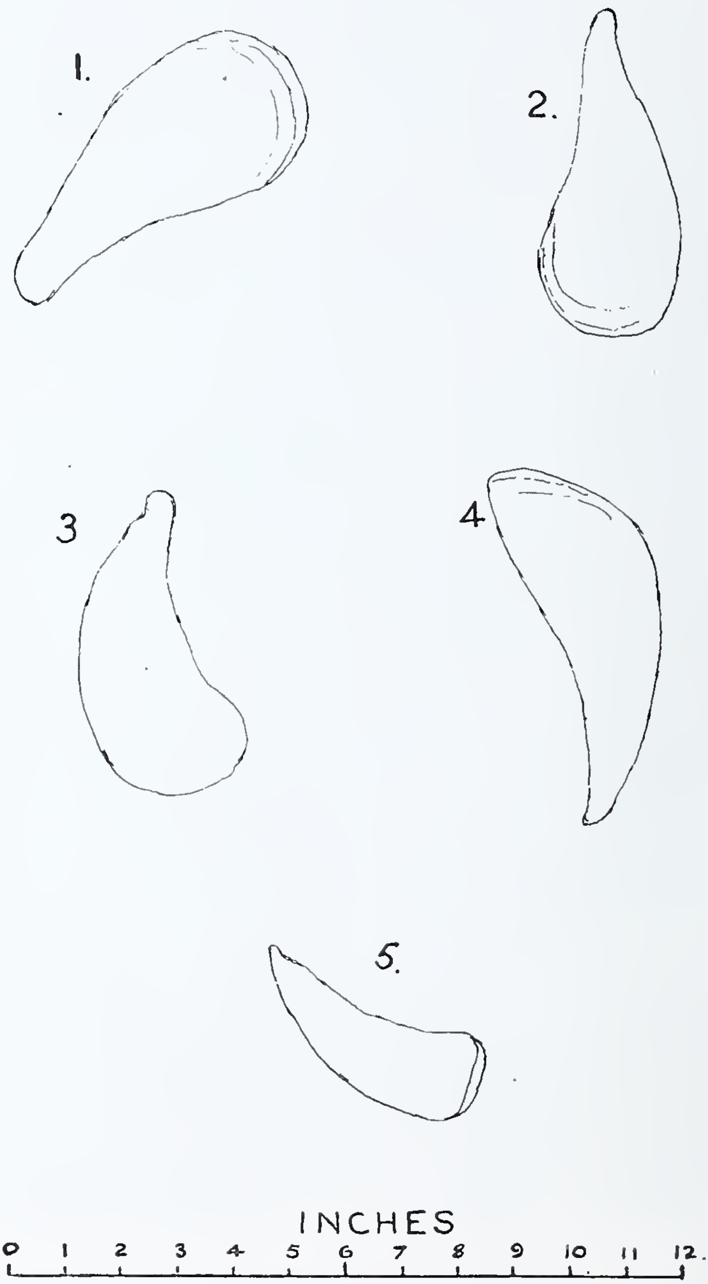
All three of the slabs contain their tracks in a brittle and easily scratched and detached thin clayey layer, covering the more solid sandstone beneath. Two of them, B and C, besides others containing impressions of algæ, are at present in my possession.

In my eagerness to view the impressions on the first slab found, I examined it at night, by lamp-light. The attempt was a revelation. The light, falling obliquely upon the surface of the stone, brought into prominence every projection and depression. Tracks plain by daylight were made much plainer, whilst impressions indistinct by daylight could easily be traced by lamp-light. Some tracks were found at night which I had entirely failed to see by day.

The effect was new to me and I state it here in order that any one interested who has not examined such slabs at night, by the aid of light falling upon the surface from different directions, at varying angles, may be induced to try it. Moreover without such examination some of the tracks illustrated could not be easily traced on the stones which I have described.

PL. 5.

FOSSIL IMPRESSIONS?
IN SANDSTONE SLABS
1, 2 & 3. SEE PLATE I.



Supplement to "The Discovery of Fossils in the Triassic of York County, Pennsylvania."

Since the preparation of the paper announcing the discovery of fossils in the Triassic of our county, I have found the same fossil algæ therein described at another point, distant about four miles eastward from the first locality.

The fossil-bearing deposit in this second exposure is an argillaceous, soft, bluish-grey rock, in which the fossil plants are imbedded, lying in different directions. Some of them penetrate the matrix to the depth of an inch or more. The fossil plants on the red sandstones, previously examined, covered only the surface, and did not to any extent penetrate the stone.

A difference indicative of a strong current during the accumulation of the one deposit, and of its absence in the other. The difference in the composition of the two formations also indicates the prevalence of the same conditions, the one being a sand stone and the other a clay stone.

Red sandstone, much fractured, is found immediately above the argillaceous rock, but a careful search therein over the small area exposed failed to reveal the presence of any fossils.

The illustrations on plate 13 are intended to show the manner in which the algæ are disseminated throughout the matrix.

In fig. 1 are a number of vertical stems which penetrate the rock to an unknown depth.

Figs. 2 and 3 show the extent of penetration in two other specimens.

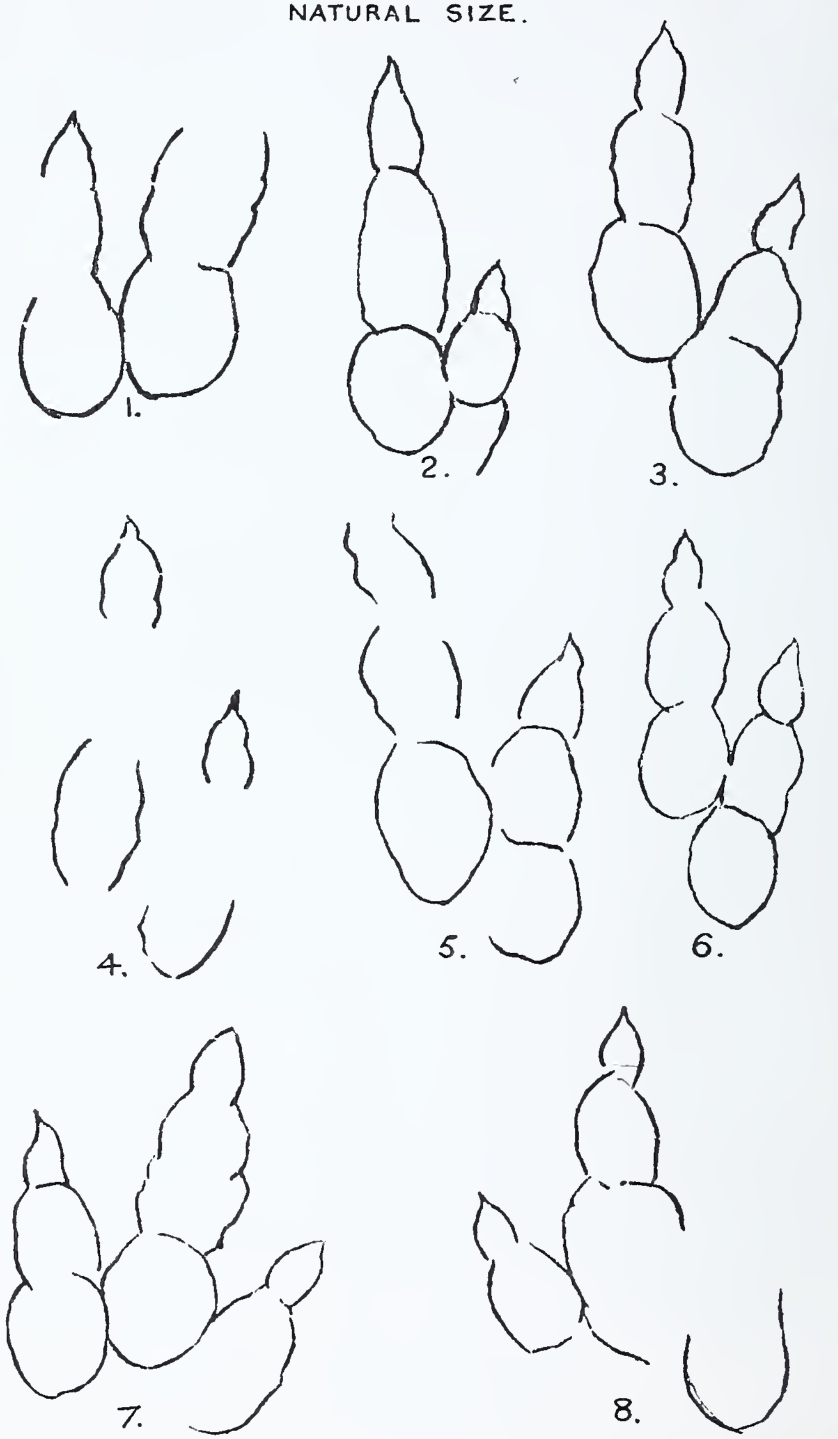
In all cases where circular sections appear, the stems have been broken off and must have extended, prior to fracture, into the overlying layers of rock.

In case these fossil plants are new, I suggest the name *Ramulus rugosus.*

PL. 6.

FOSSIL TRACKS ON SANDSTONE SLAB A.

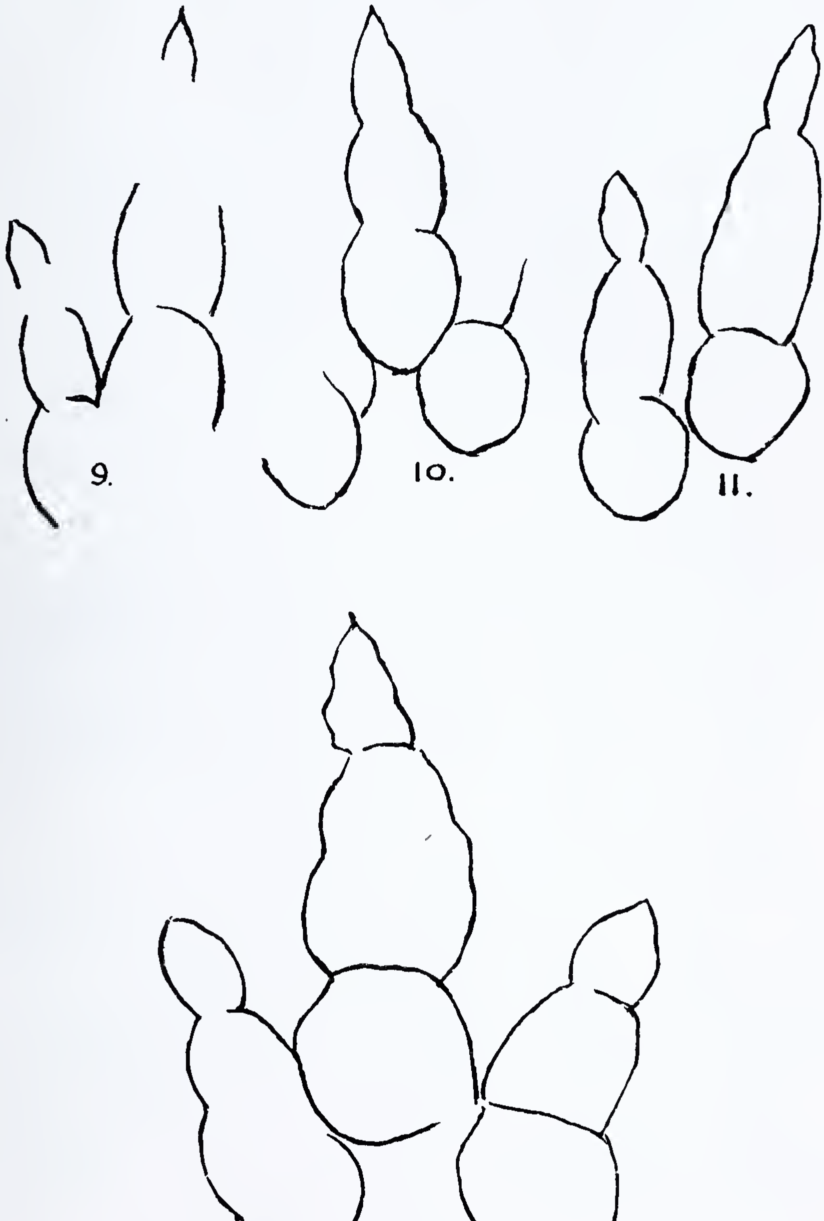
NATURAL SIZE.



PL. 7.

FOSSIL TRACKS ON SANDSTONE SLAB A.

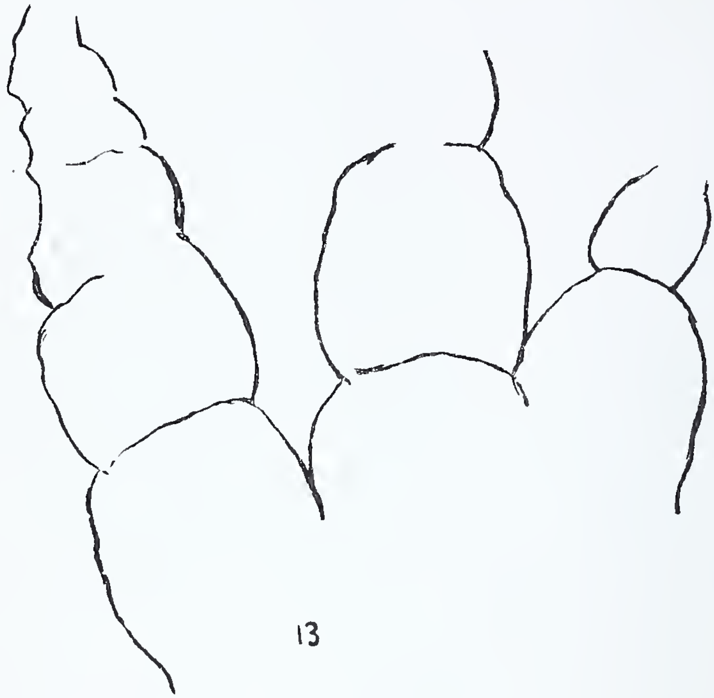
NATURAL SIZE.



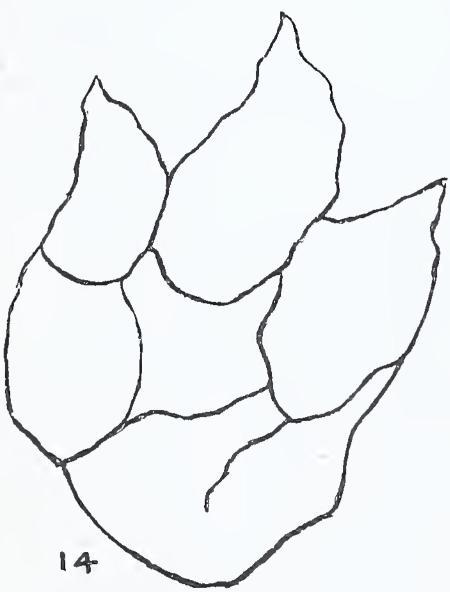
PL. 8.

FOSSIL TRACKS ON SANDSTONE SLAB A.

NATURAL SIZE.

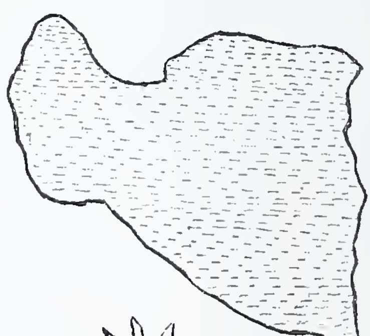


13



14

15

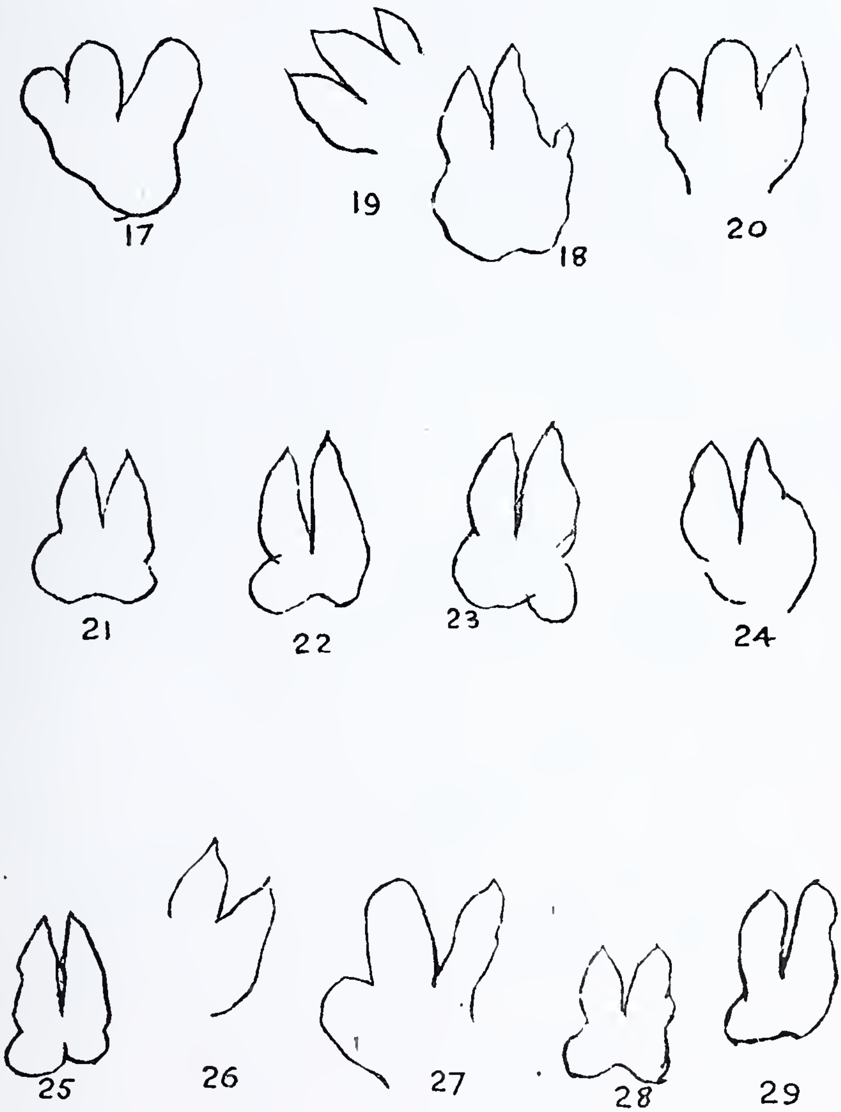


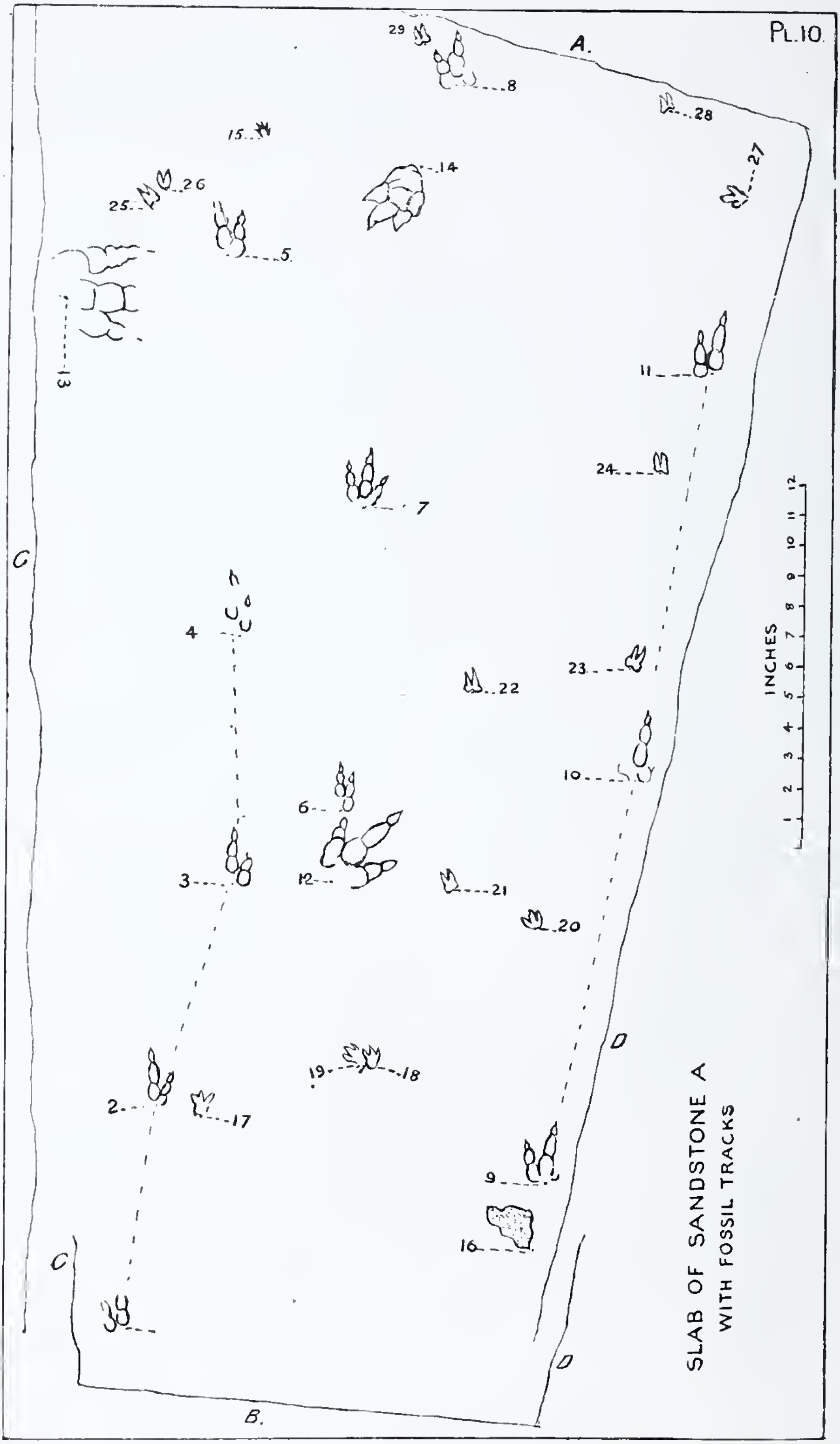
16

PL. 9.

FOSSIL TRACKS ON SANDSTONE SLAB A.

NATURAL SIZE.

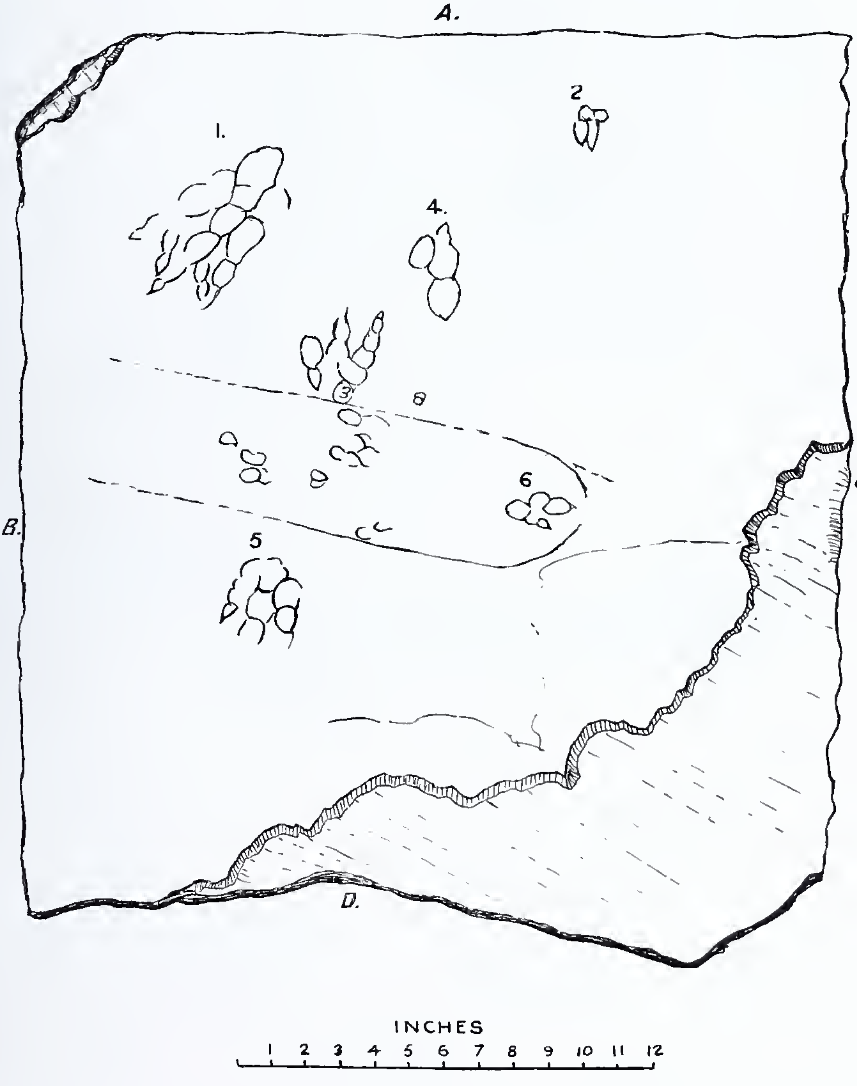


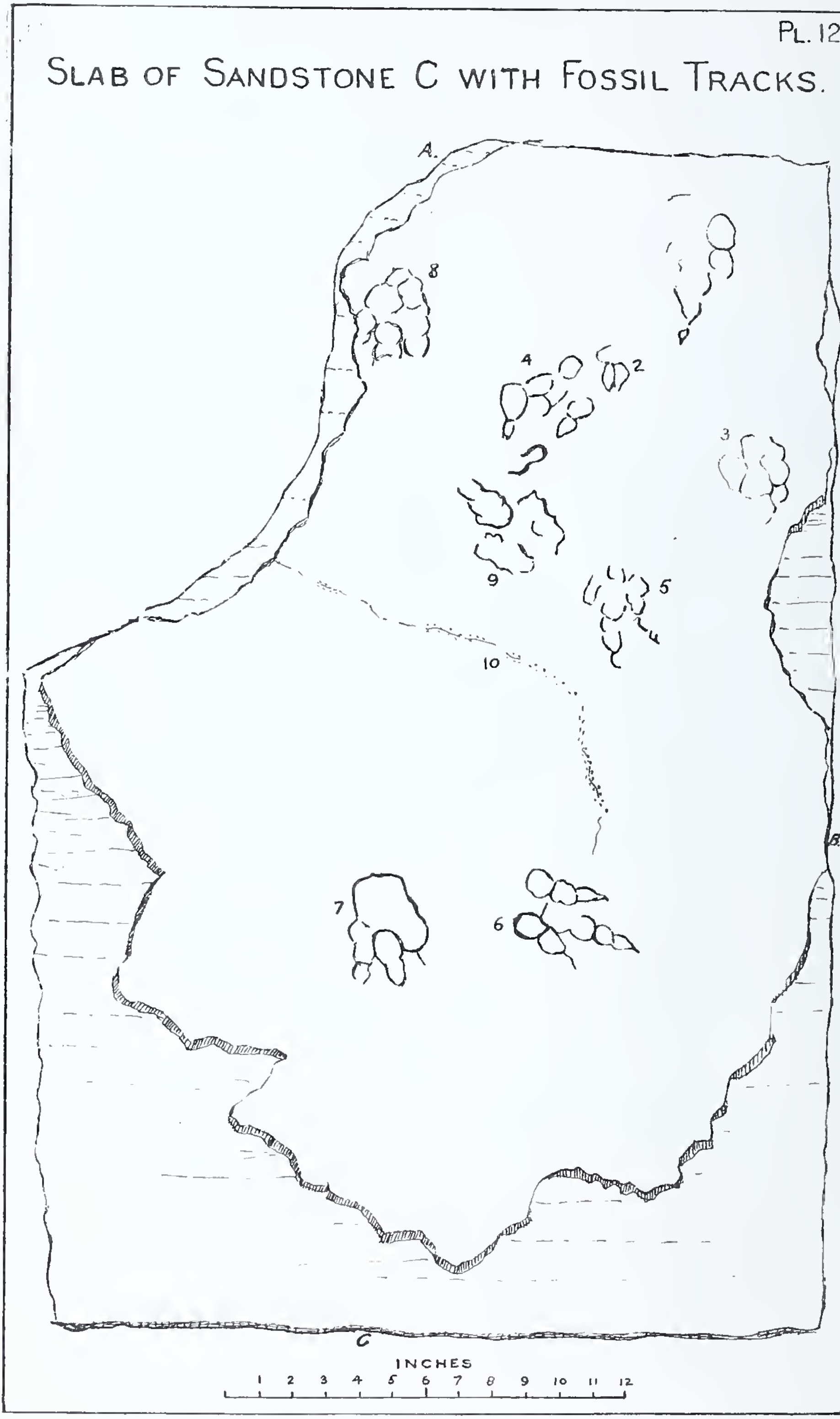


SLAB OF SANDSTONE A
WITH FOSSIL TRACKS

Pl. II.

Slab of Sandstone B with Fossil Tracks

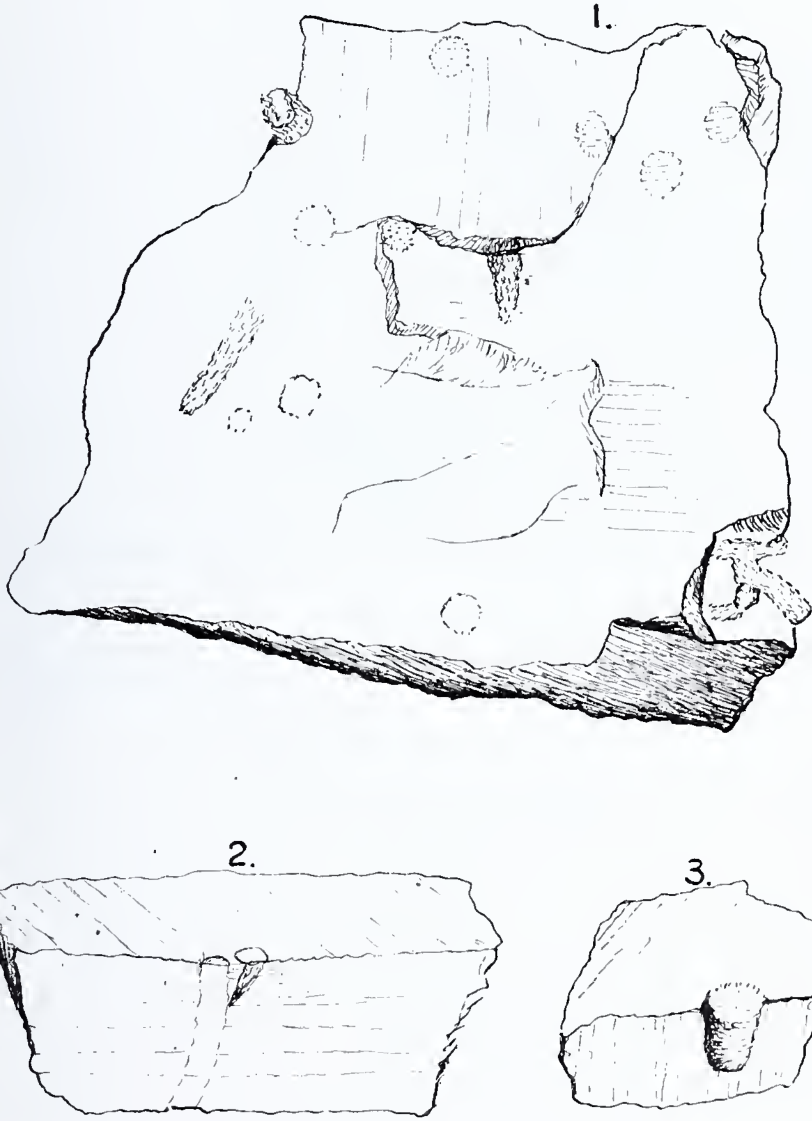



PL. 12
SLAB OF SANDSTONE C WITH FOSSIL TRACKS.
A.
8
4
2
3
9
5
10
B.
7
6
C
INCHES
1 2 3 4 5 6 7 8 9 10 11 12

PL. 13

FOSSIL ALGAE FROM THE TRIASSIC
OF YORK COUNTY, PA.

NATURAL SIZE



*Report on the New Boston and Morea Coal Lands, in Schuylkill County, Pennsylvania; accompanied by a Geological and Topographical Map.**

By Benjamin Smith Lyman.

1. Situation.

The New Boston and Morea Coal Lands lie on Mill creek near its head, on Broad mountain, and at the southern edge of Mahanoy township, in Schuylkill county, Pennsylvania; and are in the form of a parallelogram about three miles and a quarter long east-northeast and west-southwest by about three-quarters of a mile wide, with a nearly rectangular notch, a mile and a third long by three-sixteenths of a mile wide, cut out along the middle of the southern edge. The eastern half of the northern edge is three-quarters of a mile in a straight line south of Mahanoy City; the northwest corner is a mile and a half southeast of Shenandoah. The village of New Boston is just inside the middle of the northern edge of the tract; and the new village of Morea is about a mile further southwest. The Pennsylvania Railroad, Schuylkill Valley division, passes along the southern edge of both those villages, with stations at ten and eight and a half miles from Pottsville, or one hundred and four and a half and one hundred and three miles from Philadelphia, joining the Lehigh Valley Railroad near the northeast corner of the tract, at about one hundred and twenty-four miles from Philadelphia and about one hundred and sixty miles from New York by that line. The New Boston coal mines extend from three hundred yards south of the west end of the village of that name to within a couple of hundred yards of the east end of the tract; and the Morea mines have lately been opened by a pair of slopes at about a quarter of a mile south of the village of the same name. The old village of the Glendower mine was at the present Morea rail-

* Presented to the Geological Survey of Pennsylvania, by Warren Delano, Esq., for publication.

road station; and the old Glendower mine was a quarter of a mile further southwest. The place of the old mine is now commonly called Old Boston.

The whole tract is divided in two by leases for those mines with a common boundary just west of New Boston village. The whole tract consisted originally of three tracts: the Christopher Dimm, or Ulin tract, of about four hundred and twenty-eight acres, east of the notch in the southern border; the Andrew Lytle, or Myerville tract, of about four hundred and sixty-six acres, north of the notch; and the John Cole, or Morea tract, of abont four hundred and forty-six acres west of it; in all about 1340 acres. The three original tracts were all granted by the Government in September, 1784 (except possibly the Ulin tract at another date), and the tract names were affixed at that time.

2. *Lay of the Land.*

The northern boundary of the tract lies about the top of the ridge called Mahanoy mountain, and the southern boundary lines are high up the northern slope of the next subordinate ridge of Broad mountain, or Broad mountain proper, but is somewhat short of its top. Between the two ridges, and running westerly lengthwise through the middle of the tract flows Mill creek, turning a little more southward as it approaches the western boundary and much more so just outside of it to its junction with Eisenhut's run near the southeast corner. Mill creek is but a small brook where it enters the tract on the east, near the Broad Mountain House, a wayside tavern on the St. Clair and Mahanoy City road, and is only abont eight feet wide at the western boundary. In the central part of the tract, however, it spreads out to a width of nearly one hundred and fifty yards in time of high water, carrying with it black coal dirt from the New Boston heaps. For a few score yards either side of the creek the ground is low and flat and in wet seasons inclined to swampiness, but then rises rather steeply north and south to hills a couple of hundred feet high with a few scattered cliffs, and strewn in many places with blocks of stone, many of them large, especially on the north. There

are two very small branch streams on the south, in the eastern half of the tract and the hillsides elsewhere are indented with little hollows here and there; and towards the northwest corner with a broad one. The tract all lies between the height of about 1420 feet above mean ocean level, at the western boundary, and about 1725 feet above the same level, near the northeast corner. Mill creek falls about one hundred and eighty feet on its way through the tract. The Pennsylvania railroad, Schuylkill Valley division, runs lengthwise of the tract, near the north bank of the creek, from the western boundary to about three-quarters of a mile east of New Boston village and then turns northeastward and leaves the tract just where it joins the Lehigh Valley railroad, at New Boston Junction. The Lehigh Valley railroad by a branch from that point passes around the upper part of Mill Creek valley just inside the eastern boundary and thence westerly again and crossing the creek once more reaches the New Boston breaker some three hundred yards southeast of the village. A small branch also goes westward from the breaker to join the Pennsylvania railroad. Another branch from the Pennsylvania railroad enters the tract near the southwest corner and goes eastward, nearly parallel to the southern boundary as far as to the Morea breaker; and a branch in the same direction runs thence to the Lehigh Valley railroad branch southeast of the New Boston breaker.

A large wagon road from Mahanoy City to St. Clair crosses the northeast corner of the tract and again the southeast corner, branching off near there towards Tamaqua. Another large wagon road comes from Mahanoy City to New Boston village, about a mile and a-half, and a new one, mainly an old one rebuilt, a little west of that comes from Mahanoy City to Morea village; and thence an old rough narrow road runs westward through the tract towards New Castle, branching off southwesterly past the southwest corner of the tract towards St. Clair. There are several other dim old tracks and wood roads here and there connecting with those main roads.

3. *Geology.*

Structure.—The rocks of the tract lie mainly in basin shape with the bottom, or axis, of the basin, or synclinal, underlying the general course of Mill creek, and the sides of the basin rising on either side, as the ridges do, north and south of the creek, but much more steeply than the surface of the ground rises, at about 2500 feet south of the axis of the basin and near the southern edge of the tract, the rocks form a saddle, or anticlinal, and descend again southward. On the other hand, near the northern edge of the tract, and about 2000 feet north of the axis of the basin, the rocks form another saddle, and descend to the north, into the Mahanoy valley.

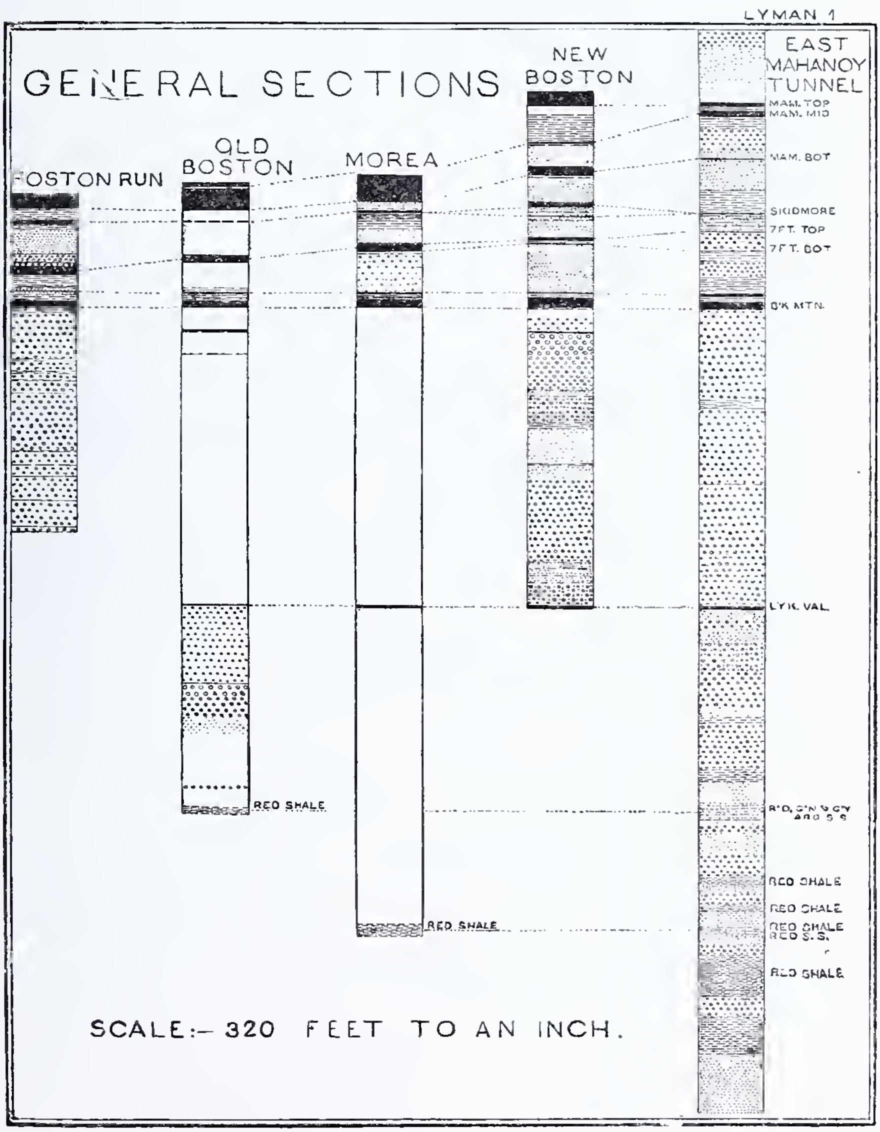
The basin flattens out in rising gently towards the eastern end of the tract, and in that part is commonly called "the spoon of the basin" from the resemblance of the shape of the coal beds there to the shallow form of the hollow of a spoon. But near the New Boston breaker, and still more westward, the basin becomes a rather sharp deep fold, with steep sides, though the bottom of a coal bed at the axis in it descends only about one foot in 235 between New Boston and Old Boston.

The position of the two saddle axes, north and south of the basin, is somewhat less precisely known than that of the basin axis, but has been ascertained quite near enough probably for any practical interest that concerns the present tract. The northern saddle axis appears not to be quite parallel to the basin axis, but to diverge a little more from the basin axis towards the western end of the tract than at the east. The southern saddle axis is perhaps more strictly parallel to the basin axis.

Rock Beds.—The rock beds exposed on the tract, in all about 1600 feet in thickness, belong to the lower part of the coal measures; No. XIII of the old Pennsylvania survey, about 400 feet; to the Pottsville conglomerate No. XII, about 350 feet; and to the Mauch Chunk red shale, No. XI, about 350 feet.

East Mahanoy Tunnel Section.—The same series of rocks, almost exactly, has been completely and consecu-

tively exposed by the East Mahanoy tunnel of the Philadelphia and Reading railroad, at a mile and three-quarters northeast of the northeast corner of the New Boston tract; and, though differing, of course, in some details from what we have upon the tract, will be very useful for comparison. In particular it gives more fully and exactly than we have otherwise the means of determining the thickness of the beds of No. XII. and No. XI. It is therefore given as follows (see the drawing below),



according to measurements from the cross-section drawn on the State Geological Survey's Western Middle Coal Field cross-section sheet No. 1, since that seems to be the most correct information at hand in regard to the rocks of the tunnel:—

Conglomerate, about	25′	0″
Sandstone, about	82′	0″
COAL BED, *Mammoth top split*, about	7	0″
Slate, about	7′	0′
COAL BED, *Mammoth middle split*, about	8′	0″
Slate, about	20′	0′
Conglomerate, about	32′	0″
Sandstone, about	10	0″
COAL BED, *Mammoth bottom split*,	2′	6″
Sandstone, about	45′	0″
Slate, about	35′	0″
COAL BED, *Skidmore*,	1′	6″
Slate and sandstone, about	23′	0″
COAL BED, *Seven-foot top split*,	1′	0″
Conglomerate, about	28′	8″
COAL BED, *Seven-foot bottom split*,	1′	4″
Slate, about	15′	0″
Conglomerate, about	25′	0″
Slate, about	22′	0″
COAL BED, *Buck Mountain top split, or rider*,	4′	0″
(Slate) about	9′	0″
COAL BED, *Buck Mountain bed*,	11′	0″
Conglomerate, top of No. XII, about	140′	0″
Slate, about	11′	0″
Conglomerate, about	295′	0″
COAL BED, *Lykens Valley*,	3′	0″
Sandstone, about	20′	0″
Conglomorate, about	10′	0″
Sandstone, about	20′	0″
Sandstone and conglomerate, about	45′	0″
Conglomerate, about	55′	0″
Sandstone, about	15′	0″
Shale, about	8′	0″
Conglomerate, about	72′	0″
Shale, about	18′	0″
Sandstone, about	65′	0′
Conglomerate, about	7′	0″
Sandstone, about	35′	0′
Conglomerate, about	35′	0″
Red shale, "top of No. XI," called	15′	0′
Sandstone, about	12′	0″
Conglomerate, about	18′	0″
Red shale, about	10′	0′
Standstone, about	50′	0″
Conglomerate, about	15′	0″

Red shale, about	60′	0″
Conglomerate with green matrix, about	30′	0″
Green shale, about	60′	0″
Sandstone, about	90′	0″
	1,629′	0″

Taking only the coal beds and the barren intervals we have then, the following section:

Interval,	107′	0″
Mammoth top split,	7′	0″
Interval,	7′	0″
Mammoth middle split,	8′	0″
Interval,	62′	0″
Mammoth bottom split,	2′	6″
Interval,	80′	0″
Skidmore,	1′	6″
Interval,	23′	0′
Seven-foot top split,	1′	0″
Interval,	28′	8″
Seven-foot bottom split,	1′	4″
Interval,	62′	0″
Buck Mountain top split,	4′	0′
Interval,	9′	0″
Buck Mountain bottom split,	11′	0″
Interval, top of XII,	446′	0″
Lykens Valley coal bed,	3′	0″
Interval, to top of the red shale of XI,	405′	0′
Interval, in the red shale of XI,	360′	0″
	1,629′	0″

A more detailed measurement of the same section is given in a later publication of the State Geological Survey, the annual report for 1886, part III, page 1300; but, as it seems on the whole, less correctly. The intervals between the coal beds are in some cases decidedly different, and were probably computed for dips different from what the printed cross-section appears to give, and perhaps were based on less exact measurements in the tunnel long after its completion. Possibly, too, there was an unconscious leaning towards a lessening of some of the intervals, by reckoning on a flatter dip than what would have been the true one, in order to confirm an identification of the beds with those of the Morris colliery on the opposite side of the Mahanoy basin, as indicated on the printed cross-section. But that identification seems clearly to be incorrect. Nevertheless, for the sake of comparison, and for some details omitted

from the printed cross-section, the columnar section of the annual report may well be given, with corrected identification of some of the coal beds, as follows, from above downwards (without drawing except the insertion of a few beds in the section already given, page 41) :—

Conglomerate,	16′	11″
Sandstone,	12′	8″
Sandstone,	32′	2″
Coarse sandstone,	21′	2″
COAL BED, (*Mammoth top split*),	8′	0″
Slate,	2′	10″
Shelly sandstone,	5′	0″
COAL BED, (*Mammoth middle split*),	8′	0″
Blue slate,	4′	11″
Pea and mustard seed conglomerate,	16′	11″
Sandstone full of quartz veins,	12′	11″
Sandstone and conglomerate	3′	4″
COAL BED, (*Mammoth bottom split*),	2	6″
Slate,	1′	7″
Sandstone,	11′	7″
Slate,	2′	0″
Hard massive sandstone,	18′	4″
Dark slate,	5′	6″
COAL BED, (*Skidmore*),	1′	0″
Soft slate,	7′	4″
Hard sandy slate,	20′	10″
COAL BED, (*Seven-foot top split*),	1′	6″
Blue slate,	13′	6″
Sandstone,	2′	0″
Slate,	2′	11″
Sandy slate,	3′	7″
Blue slate,	3′	0″
Dark gray slaty sandstone,	6′	8″
Slate,	0′	4″
Pea conglomerate with quartz veins,	30′	7″
COAL BED, (*Seven-foot bottom split*),	1′	4″
Dark bluish gray slate,	14′	5″
Sandstone,	3′	7′
Hard conglomerate,	16′	2″
Hard dark sandstone, massive bottom, slaty top	23′	7″
COAL BED, (*Buck Mountain top split*),	4′	0″
Slate,	4′	6″
COAL BED, (*Buck Mountain*),	10′	11″
Slate,	0′	11″
Hickory and walnut conglomerate with occasional slate partings, (top of No. XI),	143′	6″
Hard sandstone,	10′	0″
Hickory nut conglomerate,	109′	0″
Slate,	0′	6″
Hickory nut conglomerate, very ferruginous,	79′	7″

Pea and hickory nut conglomerate,	70′	10″
COAL BED, (*Lykens Valley*),	3′	0″
Slate,	3′	6″
Hard massive dark gray micaceous sandstone,	12′	6″
Conglomerate,	2′	0″
Hard massive micaceous sandstone with few pebbles,	16′	10″
Hickory nut conglomerate,	11′	6″
Hard ferruginous gray sandstone,	13′	1″
Pea conglomerate containing beds of massive coarse loose Sandstone two and three feet thick,	19′	5″
Gray sandstone,	5′	0″
Hickory nut conglomerate,	19′	11″
Hard sandstone,	4′	0″
Hard massive egg conglomerate,	61′	11″
Greenish gray ferruginous and argillaceous shale,	18′	2″
Hard massive ferruginous sandstone,	10′	0″
Hard massive walnut conglomerate,	11′	0″
Hard massive gray sandstone with a few scattered pebbles,	16′	1″
Conglomerate with few pebbles,	2′	11″
Very hard massive egg and walnut conglomerate,	27′	6″
Greenish gray ferruginous shale,	18′	10′
Shaly ferruginous gray sandstone,	10′	8″
Massive greenish gray sandstone,	7′	1″
Gray sandy shale,	13′	0″
Massive false bedded, red, green and gray argillaceous sandstone	23′	5″
Mottled red, green and gray ferruginous sandstone,	2′	10″
Gray ferruginous sandstone,	2′	10″
Conglomerate,	7′	11″
Mottled red and gray shaly sandstone,	13′	7″
Hard fine grained greenish gray sandstone,	23′	5″
Hard gray conglomerate,	30′	5″
Gray sandstone,	4′	8″
Red shale (top of No. XI),	15′	5″
Red sandstone,	3′	7″
Very coarse gray sandstone,	8′	11″
Gray sandstone,	1′	9″
Red shaly sandstone,	3′	0″
Greenish and gray shaly slate,	8′	11″
Very argillaceous and shaly gray sandstone,	7′	0″
Hard gray sandstone,	2′	10″
Hard gray conglomerate,	2′	5″
Hard gray sandstone,	6′	10″
Red shale,	4′	0″
Red sandstone,	7′	6″
Fine grained gray sandstone,	16′	1″
Conglomerate with sandstone alternations,	2′	5″
Gray conglomerate, false bedded,	17′	7″
Soft red shale,	12′	1″
Red sandstone,	2′	0″

Soft red shale,	21′	11″
Red and gray mottled sandstone,	7′	6″
Soft red shale,	10′	2″
Conglomerate, greenish gray matrix,	27′	2″
Soft red shale,	24′	7″
Hard gray sandstone,	4′	0″
Hard mottled red and greenish gray shale.	23′	8″
Gray sand shale,	3′	4″
Fine grained gray sandstone,	8′	4″
Hard massive greenish gray arenaceous sandstone containing a few scattered pebbles,	22′	8″
Hard massive green sandstone,	18′	0″
Red shale,	14	2″
Green sandstone,	12′	5″
	1,509′	8″

Taking only the coal beds and the barren intervals of this record we should have, then, the following section:

Interval,	82′	11″
Mammoth top split,	8′	0″
Interval,	7′	10″
Mammoth middle split,	8′	0″
Interval,	38′	1″
Mammoth bottom split,	2′	6″
Interval,	39′	0″
Skidmore bed,	1′	0″
Interval,	28′	2″
Seven-foot top split,	1′	6″
Interval,	62′	7″
Seven-foot bottom split,	1′	4″
Interval,	57′	9″
Buck Mountain top split or rider,	4′	0″
Interval,	4′	6″
Buck Mountain bed,	10′	11″
Interval, top of XII,	414′	4″
Lykens Valley coal bed,	3′	0″
Interval, to top of red shale of XI,	414′	0″
Interval in the red shale of XI,	320′	3″
	1,509′	8″

Measuring, however, as before on the printed cross section of the State Geological Survey (Western Middle Coal Field cross-section sheet No. 1), and computing the thickness of the different portions according to the dips and horizontal distances as there drawn (and the horizontal distances agree well enough with those given in the annual report for 1886, beginning at page 1300, but with only one dip given), we have the following different intervals:

Bottom of the Buck Mountain bed to top of Lykens Valley bed,	446′	0″
Bottom of Lykens Valley bed to top of red shale of XI,	405′	0″

Although these differ from the figures of the section of the annual report previously given, they seem on the whole to be probably more correct, and have been used by us as the true extent of those intervals.

Measuring, in like manner, on the printed cross-section we have the following thickness of the portions of the different grand formations included:

Coal measures, or No. XIII,	415′	0″
Pottsville conglomerate, or No. XII,	854′	0
Mauch Chunk red shale, or No. XI,	360′	0″
	1,629′	0″

There is then, a difference of 119 feet 4 inches between this amount and the one given by the annual report of the State Survey for the whole section. The only way in which the differences in the intervals would particularly affect the results of our survey is in the distance apart of the Buck Mountain bed and the Lykens Valley bed. Since we have no better means of determining the distance we have assumed it to be the same in the tract as in the East Mahanoy tunnel. A change of 32 feet in the amount of the interval would slightly alter the place of the outcrop of the Lykens Valley coal bed, and our indication of its place on the map, then, becomes to that degree uncertain, in addition to whatever other uncertainty there may be about it. But, as already said, the extent of the interval that we have adopted seems to be, on the whole, the one that is most likely to be correct, and is rather confirmed by our work on the tract.

It may be noticed that the red shale passes upwards into the conglomerate with alternating beds of the two kinds of rock for some space, so that there might be a difference of opinion as to where the best dividing line between the two formations should be placed. It appears too that certain beds of shale are in some places red that are not so in others, or else that they thin out and disappear, for near

the southwest corner of the present tract such decidedly marked red shale occurs at only about 300 feet below the Lykens Valley coal bed, instead of 405 feet, and red shale is said to occur likewise at the Pennsylvania railroad reservoir, near the southeast corner of the tract, which must also be within some 300 feet of the Lykens Valley coal bed.

A like difficulty might be raised as regards the upper limit of the Pottsville conglomerate, or No. XII; for, although in the section just given there is no coal between the Buck Mountain bed and the Lykens valley bed, there is a bed over two feet thick, and therefore possibly workable at some future day, only 35 feet below the Buck Mountain bed in the western part at least of the tract, as seen at several places. The dividing line between XIII and XII, then, would at the East Mahanoy tunnel seem to be immediately below the Buck Mountain bed, but not exactly so in the western part of the present tract, judging by the lower limit of the coal beds. We have no information however, as to the care with which the tunnel rocks were measured or by whom, and possibly a small coal bed there may have been thought not worth noticing. The upper limit of conglomerate rock is a still less precise guide, for several beds of it are found in the tract and to the westward that are above some of the larger coal beds, and coarse conglomerate too. But happily these difficulties about ascertaining the exact line of division between the grand formations have no bearing upon the practical working of the coal beds, except to show that beds of red shale may occur in the midst of the conglomerate not far from the Lykens Valley coal and that beds of conglomerate may occur in the midst of the productive coal measures, and that we must not be too much influenced by those circumstances.

New Boston Section.—The rocks exposed in the New Boston coal lease give us the following section, from above downwards (see the drawing on page 41), noting however, that the position of the Lykens Valley coal in this section is assumed to be at the same distance from the Buck

Mountain bed as in the East Mahanoy tunnel, our fullest and most exact source of information, a distance that agrees quite satisfactorily with what would be gathered from the less complete and precise facts observed at New Boston :—

COAL BED, *Mammoth top split,*	20′	6″
Hidden, about	15′	0″
Slate, about	40′	0″
COAL BED, *Mammoth middle split,*	2′	9″
Slate,	3′	3″
Sandstone,	22′	7″
COAL BED, *Mammoth bottom split,*	12′	7″
Slate and sandy shale ("slate rock"),	4′	0″
Hard sandstone,	39′	6″
COAL BED, *Skidmore,*	7′	5″
Slate,	0′	7″
Sandstone,	9′	10″
Sandstone and sandy shale ("sandstone slate"),	4′	1″
COAL BED (a bottom split from the Skidmore?),	0′	7″
Sandstone and sandy shale ("sandstone slate"),	5′	0″
Hard rock (sandstone?),	20′	5 ′
Sandy shale ("sandstone slate"),	0′	5″
Slate,	1′	1″
COAL BED, *Seven-foot top split,*	2′	9″
Slate,	0′	7″
Sandstone and sandy shale ("sandstone slate"),	5′	10″
COAL BED, *Seven-foot bottom split,*	0′	10″
Sandstone and sandy shale ("sandstone slate"),	4′	2″
Hard rock (sandstone?),	70′	0″
COAL BED, *Buck Mountain top split or rider,*	1	7″
Slate,	5′	0″
COAL BED, *Buck Mountain bed,*	15′	2″
Slate, about	5′	0″
Hidden, about	12′	0″
Hidden here (but at Old Boston coarse sandrock and fine pebble rock), about	18′	0″
COAL, *Spring coal bed's* place, not exposed here,	2′	0″
Egg and nut whitish gray pebble rock, about	35′	0″
Black streak, about	0′	0″
Reddish gray nut pebble rock, about	40′	0″
Dark reddish bean pebble rock, about	10′	0″
Dark greenish gray coarse sandrock, with some shaly layers, about	10′	0″
Light brownish gray and greenish gray pebbly sand rock with red streaks, about	40′	0″
Gray shale, about	10′	0″
Dark gray coarse sand rock with pea pebbles, about	50′	0″
Greenish gray shale, about	3′	0″
Reddish gray coarse, pebbly sand rock, about	20′	0″
Light brownish gray bean pebble rock, about	125′	0′

4

Shaly sand rock, about	30′	0″
Bean pebble rock and sand rock, about	36′	0″
COAL BED, *Lykens Valley*, perhaps, ...	2′	10″
	764′	4 ′

The part of the section from below the top split of the Mammoth as far down as the Buck Mountain bed is taken from the tunnel and the horizontal bore hole at the end of the tunnel in the New Boston mines, except that the thickness of the coal beds is given according to the average of several measurements in the mines to be mentioned in detail farther on, including (for this general section) in the thickness of each coal bed all its inter-bedded layers of shale, slate or bone. The original measurements in the tunnel, as recorded at the colliery, were horizontal, and have been so corrected here according to the varying dip observed from place to place and recorded at the same time with the measurements, as to give the thickness across the beds at right angles with their surfaces. A similar correction was made in the section recorded by the State Survey, but less completely and accurately, since no regard was had to the changes of dip, and only one uniform dip, was reckoned, as in fact the cross-section is drawn in the printed sections of the State Survey. The result consequently differs a little. Moreover, in the section just given, the thickness of the beds crossed twice by the bore hole, above the bottom split of the Mammoth, is given as the mean of what the two measurements would give. The description of the different kinds of rock in the original record uses some local miner's terms that are here given their probable meaning.

The part of the section below the Buck Mountain bed is taken somewhat roughly from the exposures in and near the railroad cutting just southwest of New Boston junction. The place of the Spring coal bed is indicated though the bed has not been seen on the New Boston lease, the Lykens Valley coal bed has been found in the artesian well at the New Boston village at a depth of 190 feet, and is said to have been three feet vertical, or about 2 feet 7 inches in thickness at right angles across the bed, and it is

reported to have had about the same thickness at a depth of about thirty feet in a well in the village street. But it is said to have been formerly opened just outside the northern boundary of the New Boston lease, near the northern corner, a hundred yards south of the upper cemetery gate, and is said to have had four feet of coal together with four feet of slate, making eight feet in all; information obtained latterly by Mr. Wm. H. Carter from one of the men who helped to dig the trial pits there many years ago.

Morea Section.—At and near the new Morea mines the rocks exposed give the following less full section, from above downwards (see the drawing on page 41), assuming here, too, for the same reasons as at New Boston, that the Lykens Valley coal is at the same distance below the Buck Mountain bed as in the East Mahanoy tunnel, an assumption not at all inconsistent with what facts could be observed on the spot:—

COAL BED, *Mammoth middle and bottom splits*, perhaps	41′	0″
Rather fine-grained very hard sand rock,	9′	0″
Fine-grained sandy shale,	4′	0″
COAL BED, *Skidmore*,	3′	6″
Black slate,	14′	3″
Dark gray shale,	8′	6″
Fine-grained hard sand rock,	21′	3″
COAL BED, *Seven-foot*,	13′	4″
Blackish gray hard shale,	3′	4″
Peppercorn pebble rock, very hard,	58′	8″
COAL BED, "*Leader*," *or Buck Mountain top split*,	0′	6″
Blackish gray shale, "top rock,"	10′	9″
COAL BED, *Buck Mountain*,	11′	9″
Hidden,	446′	0″
COAL BED, *Lykens Valley*, perhaps,	2′	6″
Hidden,	475′	0″
Red shale, of No. XI,	18′	0″
	1,141′	4″

The upper part of the section as far down as the Buck Mountain bed is from our measurements in the New Morea mine, chiefly in the tunnel across the measures, the thickness of the rocks between the coal beds being deduced from the horizontal measurements and the dips taken here and

there. The thickness of the Mammoth bed, however, is conjectured to be about the same as at Old Boston, where it was measured by G. K. Smith, under circumstances more favorable for exactness; for in the Morea mine it is only seen at the bottom of the basin, where it is evidently much thickened up locally, as it is also at the bottom of the basin at Old Boston. The Buck Mountain bed is given in the section with the average thickness of three measurements at different points, one of them by Mr. Fritz, as will be mentioned in detail further on. All the coal beds are given here without special mention of the included benches and the layers of slate or bone, which are to be particularly described on another page.

The Lykens Valley coal bed given in the section was opened many years ago on the mountain, a quarter of a mile northwest from Morea station, and is said to have been found to be about two feet and a half thick there. Mr. Harry Manger is so quoted as an eye witness.

The red shale of XI at the bottom of the section was bored through in the artesian well near the Morea breaker at a depth of eight hundred and seventy-eight feet to the bottom, with a vertical thickness of twenty-four feet, as the dip is there. It was called the top of the red shale there; but would seem to correspond better with some thinner layers of red shale and red sandstone not far above the top of the thick, sixty foot bed of red shale in the East Mahanoy tunnel section, which is one hundred and twenty feet below the top of the red shale of that section. In the artesian well, however, the upper, thin beds of red shale were perhaps not regarded as of enough importance to mention; and Mr. E. L. Bullock, superintendent at Morea, writes under date of 10th November. 1888: "I do not believe any accurate records were kept of the various changes in the strata, they were so frequent, but all in the conglomerate and green sandstone, never very distinct and separate from each other. No vein or trace was struck that I have any report of,—a few streaks of black slate. The well will give you the floor of the conglomerate and green sandstone." It is possible that the formation No. XII may be one hun-

dred and twenty feet thicker here than at the East Mahanoy tunnel, or rather that the two upper thin layers of red shale of the tunnel have thinned out and disappeared at Morea; but in the absence of any well record, it seems more probable that some thin red shale layers in the well were not considered by the borers worth mentioning. Indeed, it seems as if the well must have, in its upper part, passed through the red shale already spoken of as occurring near the southwest corner of the tract at only some three hundred feet below the Lykens Valley bed.

Old Boston Section.—The old Glendower mine, of thirty-five years ago (now commonly called Old Boston), and some trial pits made at that time by Mr. G. K. Smith, and partly reopened by us in 1887, with some further observations a little southward have given the following still less complete section, from above downwards (see the drawing on page 41), assuming for the same reasons as before that the Lykens Valley coal bed is at the same distance below the Buck Mountain bed as in the East Mahanoy tunnel.

COAL BED, *Mammoth middle and bottom splits*, . .	40′	9″
Hidden, including the *Skidmore coal*, not measured here, about	65′	0″
Slate, perhaps	5′	0″
COAL BED, *Seven-foot*, ...	8′	5″
Slate, perhaps	4′	6″
Hidden, perhaps	35′	0″
Slate, perhaps	6′	6″
Rock, ...	0′	6″
COAL BED, *Buck Mountain top split*, ...	2′	0″
Slate, ...	10′	6″
Rock, ...	0′	6″
COAL BED, *Buck Mountain*, ...	7′	11″
Bone and slate, ...	1′	5″
Hidden, with sandstone bottom, ...	35′	0″
COAL BED, *Spring coal bed*, ...	2′	2″
Slate, perhaps	1′	0″
Hidden, ...	34′	0″
Black slate, about	1′	0″
Hidden, ...	371′	6″
COAL BED, *Lykens Valley*, about	1′	8″
Pea pebble rock, about	117′	0″
Black streak, about	0′	0″
Egg pebble rock, about	20′	0″
Nut pebble rock, about	30′	0″
Sand rock, about	30′	0″

Hidden, about	75′	0″
Nut pebble rock, about	1′	0″
Hidden, about	30′	0″
Red shale, about	10′	0″
	947′	4″

The section down to the Spring coal bed is taken from a drawing by Mr. G. K. Smith, on a map of his dated January, 1855, except that the Mammoth top split is taken from a previous drawing of his on another map, measuring at right angles across the bed at the least distorted of three observed points, and except also that the thickness given for the Buck Mountain bed is the average of three measurements near Old Boston, including Mr. G. K. Smith's single one, as will be explained in detail further on. The Skidmore coal though not appearing in this section, seems really to have been dug into on the south side of the basin by Mr. G. K. Smith, but to have been taken to be the lower part of the Mammoth bed, and no measurement of it is given. Some differing measurements of the Buck Mountain top split and Spring coal beds will be noted among the details of those beds, and the benches and slate or bone layers of all the coal beds will be given under the separate discussion of the different beds.

The red shale at the bottom of the section is exposed near the southwest corner of the tract, and is about 100 feet above the uppermost red shale of XI of the East Mahanoy tunnel, as already pointed out.

Boston Run Section.—The new Boston Run colliery tunnel, second lift of the slope, about a mile northwesterly from the old Glendower (Old Boston) mine, with the addition of the rocks below the coal beds as found by the Pott Run tunnel about half a mile more easterly, gives according to the State Geological Survey's annual report for 1886, pages 1280 and 1281, the following section from above downwards (see the drawing on page 41), that will be, though outside the present tract, very useful for further comparison and information as to the probable changes in the coal beds within the tract:—

COAL BED, *Mammoth bottom split,*	22′	3″
Hard slate,	19′	10″

COAL BED, *Skidmore*,	5′	2″
Slate,	7′	8″
Sandstone,	8′	10″
Hard gray sandstone,	10′	5″
Fine conglomerate,	17′	10″
Hard slate, sulphur and coal,	0′	3″
Fine conglomerate,	10′	10″
Slate,	0′	1″
Fine conglomerate,	0′	9″
Hard slate and sulphur,	0′	4″
Fine conglomerate,	4′	10″
COAL BED, *Seven-foot*,	13′	10″
Slate,	16′	10″
Hard gray sandstone,	0′	6″
COAL,	0′	6″
Slate,	4′	8″
Hard sandstone,	1′	11″
COAL BED, *Buck Mountain top split or rider*,	1′	1″
Hard gray sandstone,	4′	3″
Slate,	2′	11″
Hard slate,	5′	6″
COAL BED, *Buck Mountain*,	9′	4″
Slate,	8′	6″
Conglomerate,	70′	0″
Slate,	3′	0″
Conglomerate,	16′	0″
Slate,	4′	0″
Conglomerate,	9′	6″
Slate,	1′	6″
Conglomerate,	17′	6″
Seam,	0′	0″
Conglomerate,	87′	0″
Slate,	1′	0″
Conglomerate,	18′	0″
Slate,	1′	0″
Conglomerate,	18′	0″
Seam,	0′	0″
Conglomerate,	37′	6″
Traces of coal,	0′	0″
Conglomerate,	38′	0″
Traces of coal,	0′	0″
Conglomerate,	8′	6″
	509′	5″

Comparison of the General Sections.—It is seen by the drawing of the five general sections on page 41 that the top split of the Mammoth rises, by a thickening of the intervening measures to a greater height above the Buck Mountain bed at New Boston than it has at the East Mahanoy tunnel; and that the thickening takes place especially be-

tween the top split of the Mammoth and the middle split. In fact, the middle split is nearer to the Buck Mountain at New Boston than it is at the East Mahanoy tunnel; so that. below the middle split, the measures have thinned out westerly towards New Boston. The same thinning out of the lower measures continues towards Morea and again towards Old Boston, bringing the middle split of the Mammoth nearer and nearer down towards the Buck Mountain bed; but further northwestward to Boston run colliery, there appears to be no great further change in the thickness of the measures. The thinning of the measures between New Boston and Old Boston seems to be mainly between the middle and top splits of the Mammoth, bringing them very close or quite together at Morea and Old Boston; and between the bottom split of the Mammoth and the Skidmore, bringing them from thirty or forty feet apart at New Boston to only thirteen feet apart at Morea and twenty feet at Boston run colliery. But the distances between the Skidmore and Seven-foot beds and between the Seven-foot top split and Buck Mountain beds remain almost unchanged, from New Boston to Morea, though diminishing, further westward, to Old Boston.

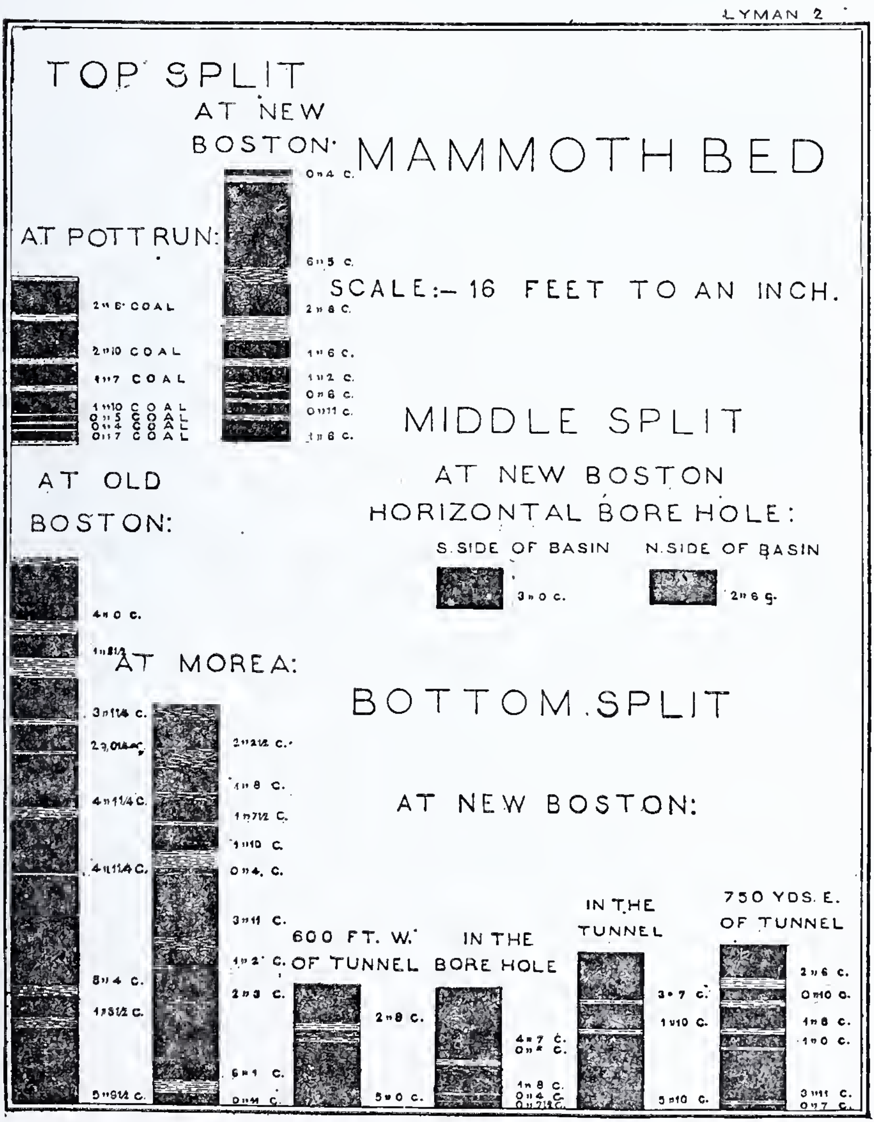
It may be thought by some that it is useless to bring into the comparison the sections of the East Mahanoy tunnel and of the Boston run colliery that are both outside of the New Boston basin. But, of course, the thickness of the rock beds, including the coals, was already acquired before the basins and saddles were formed and when the rocks all lay flat and level. The folding of the beds into waves, basins and saddles, could only change the thickness very locally; in some places, for example, by crumpling, causing the coal beds to thicken up for a small space at the bottom of a narrow basin, as at Old Boston and Morea. In other respects the relative thickness of the bed would evidently remain unchanged from what it was before the folding took place. So that it is quite proper and useful to compare neighboring sections even though they be in separate basins. Of course, too, the present shape of the surface of the ground, whether hill or valley, is still far more

recent than even the rock folding, and is yet less a bar to the comparison of adjacent sections of different valleys, though separated by important mountains.

The local variations in the thickness of the coal beds will be discussed more particularly under the heading of each bed. Other variations in the constitution of the measures may be seen by inspection of the drawings.

4. Coal Beds.

MAMMOTH BED TOP SPLIT—*New Boston.*—The top split



of the Mammoth bed has been exposed on the tract only at the old slope of the sonth side of the basin opposite the New Boston breaker. That slope was mainly a trial slope, and has been so long abandoned as now to be quite inaccessible, and appears to have been so nineteen years ago. The section of the coal bed, however, was given then by Mr. C. L. White to Mr. R. P. Rothwell, and again latterly to me by Mr. T. D. Jones, the present superintendent of the New Boston mines, as follows, from above downwards (see the drawing on page 57):

Top coal,	0	4″
Slate,	0	6″
Good coal,	6′	5″
Slate and bone,	1′	$2\frac{1}{2}$″
Good coal,	2′	6″
Slate,	1′	10″
Coal,	1′	6″
Slate,	0′	$6\frac{1}{2}$″
Coal,	1′	2″
Slate and bone,	0′	9″
Coal,	0′	6″
Slate,	0′	5″
Coal,	0′	11″
Slate,	0′	5″
Coal mixture,	1′	6″
	20′	6″

The bed, then, contains there thirteen feet four inches of coal not counting the bottom bench; and eight feet eleven inches of coal, within a thickness of ten feet one and one-half inches, are specially called good coal. But perhaps in the mere absence of any special mention it would not be fair to consider the other benches decidedly inferior.

Boston Run.—An exposure of the same bed in the workings of the Boston Run colliery, lower lift, east gangway, ninety-five feet from a point on the bottom split at 2320 feet east of the slope, and consequently about a mile northerly from Old Boston, will be useful, in the lack of other indications, to show how the thickness is likely to vary towards the western end of the tract; and the section, taken from the records of the State Geological Survey, is as follows, from above downwards (see the drawing on page 57):

Cab,	0′	3″
Coal,	2′	6″
Spar,	0′	6″
Coal,	2′	10″
Stone,	0′	6″
Coal,	1′	7″
Slate,	0′	4″
Coal,	1′	10″
Bone,	0′	1″
Coal,	0′	5″
Spar,	0′	3″
Coal,	0′	4″
Bone,	0′	1″
Coal,	0′	9″
Slate,	0′	3″
	12′	6″

The bed then, contains there 10 feet 3 inches of coal within a thickness of 12 feet. The comparison of this section with the other just previously given seems to show that the smaller thickness of the bed here arises from a thinning out of all the different benches, since nearly every bench of the New Boston exposure seems to be represented in the Boston run section, and each one to be somewhat thinner. Whether there be here any superiority of quality in the two upper thick benches, 5 feet 4 inches, as would seem to be possibly the case in the corresponding ones at New Boston, is not recorded.

The words "cab" and "spar" in the record of the section are probably local miner's terms. Cab is perhaps used for a soft shale, and spar perhaps for a hard shale. By "stone" is probably meant sandstone.

Average Thickness.—The average thickness of the bed within the tract is very difficult to estimate from such scanty materials. As the layers of slate or shale seem to diminish in thickness westward, as well as the coal, and consequently the better layers are brought nearer together and as the whole bed seems to be mined at the Boston run colliery, perhaps it will not be too unsafe to take ten feet six inches as the average thickness of the part of the bed worth working on the tract.

Quantity.—The map shows that the top split of the Mammoth bed within the New Boston lease (including the

part already mined) underlies 32 acres in basin shape, allowing ten feet all along the outcrops for the fact that the edge of the outcrop has slid more or less down hill almost everywhere, and so narrowed the extent. If we measure the extent of the bed itself, supposing it to be flattened out from the basin shape into a flat plane, we find it to be 38 acres within the New Boston lease, allowing ten feet all along the outcrops for the fact that the bed is not solid, firm coal up to the very surface of the ground.

In like manner we find the bed to underlie 29 acres of the Morea lease in basin shape, and to amount when flattened out to 37 acres of a flat plane.

For the amount in tons we must consider also the average thickness of the bed, to get the cubic contents, or cubic yards, and then multiply by the weight of a single unit or cubic yard. If we take the average thickness of coal to be ten feet six inches, as just suggested, and the specific gravity to be 1.50, or 2525 lbs. of anthracite to a cubic yard, or $1\frac{1}{8}$ tons, we should have 725,000 tons in the New Boston lease, and 705,000 tons in the Morea lease, or 1,430,000 tons in all. Apparently no part of the bed worth mentioning has been worked even at New Boston.

Quality.—We have no record in regard to the quality of the coal of the top split of the Mammoth bed on the tract, except the mention that the two thick benches near the top of the bed are good coal. The bed, however, would seem to be worked throughout at Boston run.

MAMMOTH BED MIDDLE SPLIT.—*New Boston.*—The only exposures hitherto of the middle split of the Mammoth coal bed at New Boston are in the horizontal bore hole made many years ago at the end of the tunnel in the mines. The boring record mentions no subdivision in benches nor any interbedded layers of slate or other foreign material, but merely the horizontal thickness of the bed, which gives, when reduced to the thickness across the bed at right angles to its surfaces, by correction for dip, two feet six inches on the north side of the basin and three feet on the south side (see the drawings on page 57). Nothing is recorded either in regard to the quality of the coal.

Old Boston.—The upper part of the great coal bed mined 35 years ago at Old Boston seems to correspond with the middle split of the Mammoth bed though somewhat thickened up and brought very near to the likewise much thickened bottom split of the Mammoth, making with it one enormous bed only separated into benches by comparatively small layers of slate. Probably the two upper coal benches, but possibly only the uppermost one, correspond to the middle split of the Mammoth. The section of that part of the bed at Old Boston is as follows, from above downward (see the drawing on page 57):—

Slate,	0′	8½
Coal,	4′	0″
Slate,	1′	2″
Coal,	1′	8½″
Slate, immediately overlying coal of the bottom split,	1′	7″
	9′	2″

We should have then, 5 feet 8½ inches for the thickness of coal within a total thickness of 6 feet 10½ inches, or, if only the uppermost coal bench be reckoned there would be four feet of coal. The quality is not given.

The figures are taken from measurements made at right angles across the layers on a drawing of sections and a map by Mr. G. K. Smith, apparently of the latter part of 1854. The drawing is accompanied by figures that indicate the horizontal thickness measured in a cross-cut across the bed at the least distorted of three points where cross-cuts were made. The same figures have sometimes been mistaken by others for measurements at right angles across the bed, and indeed they appear misleading.

Average Thickness of the Bed.—Here again it is very difficult to estimate the average thickness of the coal bed from such scanty information. At the Primrose colliery, about two miles northeast of New Boston, it appears from the printed cross-section of the State Geological Survey, the bed is called "the Four-foot bed," as if its thickness there were four feet. It would perhaps be safe, then, to take the average thickness to be three feet on the New Boston lease and four feet and a half on the Morea lease.

Quantity.—The map shows that the middle split of the Mammoth bed underlies, in basin shape, 78 acres within the New Boston lease, or 95 acres measured on the bed itself, as it would be if spread out flat, making in each case the same allowance as before of ten feet all along the outcrop, for the facts that the outcrops slide more or less down hill, and that the coal is not solid up to the very surface of the ground.

In like manner we find the bed to underlie in basin shape 73 acres of the Morea lease, and to have an extent of 90 acres on its own surface.

The amount in tons, reckoning in the same way as for the top split, and taking, as just suggested, three feet for the average thickness, would be 520,000 tons in the New Boston lease, and 735,000 tons in the Morea lease, or 1,255,000 tons in all. None of the bed has been worked on either lease.

Quality. — We have no information in regard to the quality of the coal of this bed at New Boston; but it would seem to be of good quality at Old Boston, and in the Primrose colliery; and it is no doubt safe to consider the bed workable throughout.

MAMMOTH BED BOTTOM SPLIT.—*East of New Boston Tunnel.*—In the New Boston mines, at a point on the gangway called one hundred and fifty yards east of the tunnel, my measurement of the bottom split of the Mammoth bed gave the following section from above downward (see the drawings on page 57):

Top rock, called a very good roof.		
Coal,	2′	6″
Slate,	0′	1″
Coal,	0′	10″
Slate,	0′	8″
Coal,	1′	8″
Slate,	0′	5″
Coal,	1′	0″
Slate,	0′	1″
Coal,	3′	11″
Slate,	0′	2″
Coal,	0′	7″
	11′	11″

The bed, then, contains here 10 feet 6 inches of coal within the total thickness of 11 feet 11 inches.

New Boston Tunnel.—In the far end of the tunnel at the New Boston mines, the bottom split of the Mammoth bed was cut across. The section of the bed at the end of the tunnel is, according to the record at the mines (after reducing the horizontal distances, with the dip, to thicknesses across the bed at right angles to its surfaces) as follows, from above downwards (see the drawing on page 57).

Coal,	3′	7″
Slate,	0′	3″
Coal,	1′	10″
Slate,	0′	5″
Coal,	5′	10″
	11′	11″

The bed, then, contains there 11 feet 3 inches of coal in a total thickness of 11 feet 11 inches.

Bore Hole.—The details of the section of the bed at the far end of the bore hole made southward across the basin from the end of the tunnel at the New Boston mines, are less sure, since it was merely a bore hole and the steepness of the dip there is not precisely known. There is, however, at the mines a record of the horizontal distances bored through in each bench, as "reported by Mr. Rich;" and, if we take the dip to be about 40 degrees, as it would appear to be from the section we have drawn across the basin there, the corresponding thicknesses across the different layers at right angles with their surfaces would give us the following section from above downwards (see the drawing on page 57):

	Horizontally.		*Thickness.*	
Top coal	7′	1½″	4′	7″
Bone,	0′	1″	0′	0½″
Coal,	0′	8″	0′	5″
Shelly coal,	0′	8″	0′	5″
Slate,	0′	9″	0′	6″
Bone,	0′	7′	0′	4½″
Coal,	2′	7″	1′	8″
Slate,	0′	3¾″	0′	2½″
Coal,	0	6″	0′	4′
Slate,	0′	0¾″	0′	0½″
Coal,	1′	0″	0′	7½″
	14′	4″	9′	2½″

Here we have, then, 8 feet and half an inch of coal within the total thickness of 9 feet 2½ inches. These figures seem, however, very small compared with the much more trustworthy measurements at the rather closely neighboring end of the tunnel just previously given; and the smallness may be due either to our taking the dip as gentler than it really is or to some lack of precision in the boring. A boring is necessarily less certain than a section exposed to view.

West of New Boston Tunnel.—In the New Boston mines at a point on the main gangway some 600 feet west of the tunnel, my measurement of the same bottom split of the Mammoth bed gave the following section from above downward (see the drawing on page 57):

Roof rock.		
Coal,	2′	9″
Slate,	0′	8″
Bony coal,	0′	6″
Slate,	0′	5″
Coal,	5′	0″
Floor, hard rock.		
	9′	4″

We have, then, here 7 feet 6 inches of coal, besides 6 inches of bony coal, all within the total thickness of 9 feet 4 inches. The whole thickness agrees quite closely with what we found just now for the bore-hole section, and tends strongly to confirm it, though the point is much more distant from the bore-hole than the tunnel section is.

Morea.—In the tunnel of the Morea mine our measurements of the part of the Mammoth bottom split that was exposed on the 16th of October, 1888, give the following section, from above downward (see the drawing on page 57):

Bone,	1′	0″
Coal, good,	2′	2½″
Coal, bony,	1′	8″
Coal, good	1′	9″
Coal, bony,	0′	7″
Coal, good,	1′	7½″
Slate,	0′	3″
Coal, good,	1′	10″
Black slate,	1′	5″
Black dirt,	0′	0½″
Coal,	0′	4

Bone,	0′	2″
Coal, good,	3′	11″
Coal, with a little bone mixed,	0′	10″
Bone,	0′	11½″
Coal,	1′	2″
Slate,	0′	4″
Coal,	2	3″
Coal, in places bony,	0′	2″
Coal,	6′	1″
Black slate,	1′	0″
Coal,	0′	11″
	30′	6″

The whole bed was not yet exposed here; but Mr. E. L. Bullock wrote on the 10th of November (our latest information in regard to the mines) that a test hole at about the axis of the basin had been made and shown the coal to extend 22 feet above the tunnel, and 38 feet below it, and the tunnel itself was 8 feet high. So that the total thickness there was 68 feet, all he says "of very fair quality considering its great thickness." But the dips in the tunnel and the condition of the coal at the point showed that the bed was much crushed and doubtless thickened up there, in the same way that it evidently is at Old Boston. It does not seem probable therefore that the bed, where comparatively undisturbed, is any thicker at Morea than it is at Old Boston; indeed, the apparent correspondence of the different benches at the two places, seems rather to make the whole bed appear to be of somewhat less thickness at Morea than at Old Boston. The two upper coal benches of Old Boston which we have taken to be the Mammoth middle split do not seem to enter into our section just given.

The portion we measured at Morea, the bottom split, perhaps entire, has several benches marked good coal; but others marked simply coal are probably just as good, and the omission to specify the quality was simply accidental. If the coal appeared bony it was in every case particularly mentioned. We have, then, of good coal 22 feet 1 inch within a total thickness of 29 feet 6 inches, besides some benches of coal, amounting to over 4 feet, that are more or less bony but may prove to be not wholly useless, and about 3 feet of decided bone, slate, and dirt, all within the same total thickness.

Old Boston.—From an old map and section drawing by Mr. G. K. Smith, apparently of the latter half of 1854, we get a section of the Mammoth bed (middle and bottom splits, the middle split already once given above) according to a cross-cut at the bottom of the shaft at Old Boston, as follows, from above downward (see the drawing on page 57):

Top rock.		
Slate,	0′	8½″
Coal,	4′	0″
Slate,	1′	2″
Coal.	1′	8½″
Slate,	1′	7″
Coal,	3′	1″
Slate,	0′	6′
Coal,	2′	1″
Slate,	0′	2″
Coal,	4′	1½″
Slate,	0′	11″
Coal,	4	1′
Slate,	0′	1″
Coal,	8′	4″
Slate and bone,	0′	8½″
Coal,	1′	8½″
Slate,	0′	10″
Coal,	5′	10′
	41′	7½″

The two upper coal benches have already been discussed as the representative here of the middle split of the Mammoth. In the remainder we have, then, 29 feet 3 inches of coal within a total thickness of 32 feet 5½ inches, the two splits giving together 34 feet 11½ inches of coal within a total thickness of 40 feet nine inches, a magnificent coal bed.

The section just given is the one represented on Mr. G. K. Smith's map as amounting to 49 feet 9 inches, and that has sometimes been taken to be the thickness across the bed at right angles to its surface. But a closer examination shows that the dimensions given by him were horizontal ones and need to be corrected for the dip in order to get the true thickness of the bed. He also gives a section across the bed near the bottom of the basin where he makes the total thickness to be 60 feet 9 inches, although in his section across the basin (on the large scale of thirty

feet to an inch) the bed measures there only 57 feet across. The bed is, however, evidently much thickened up at that point because of being at the bottom of the basin. He gives, further, a section across the bed where the shaft first enters it and gets a thickness of 78 feet 11 inches, expressly stated to be at right angles with the measures, but in the cross-section the bed is drawn as 84 feet thick there. Apparently then, the drawing at least is not very exact. The great thickness is obviously due to the folding up of the bed, as shown in his cross-section, and does not represent a single thickness of the bed. Indeed, the fold is a double one, so that parts of the bed recur in the section three times.

The quality of the different benches is given by Mr. G. K. Smith only in the section of this doubly folded portion, and even there only for some of them, and cannot therefore be transferred with any certainty to the benches of the normal condition of the bed. For example, he gives the bottom bench as "good coal," the next coal bench as "soft," and the third as "slippey," and so on. But it is quite probable that the "slippey" character may be due to the folding and crushing of the bed just here. No dependence, then, can be placed upon his statements as to the quality for an indication of the merits of the different benches in their ordinary condition, except that he gives them mostly as good coal, and they may be supposed to be at least equally good where not involved in these sharp folds.

Average Thickness.—The average thickness of the coal in the bottom split of the Mammoth bed at New Boston, according to the four sections given would be 9 feet and 4 inches within a total thickness of 10 feet and 7 inches. The number of sections is still small to base a very close average on, but they are pretty centrally situated.

On the Morea lease the Morea and Old Boston sections would give a mean, for the bottom split of the Mammoth alone, of 25 feet 8 inches of coal within a total thickness of 31 feet. Both the sections however, are some distance west of the center of the lease, and the coal, as already

seen, grows notably thinner towards New Boston. Taking this into account with due reference to the distance and amount of thinning eastward we get for the average 20 feet of coal within a total thickness of 25 feet. The number of sections is very small to base a good average upon, but the result is the best that can be had from such scanty information.

Quantity.—In the New Boston lease, the bottom split of the Mammoth, as shown on the map, underlies about 113 acres in basin shape, or if flattened out would cover 134 acres, making in each case the same allowance, as in the other beds, of ten feet subtracted all along the theoretical (and mapped) outcrops.

In like manner, on the Morea lease, we have for the same bottom split 89 acres in basin shape, and 129 acres flat or on the surface of the bed.

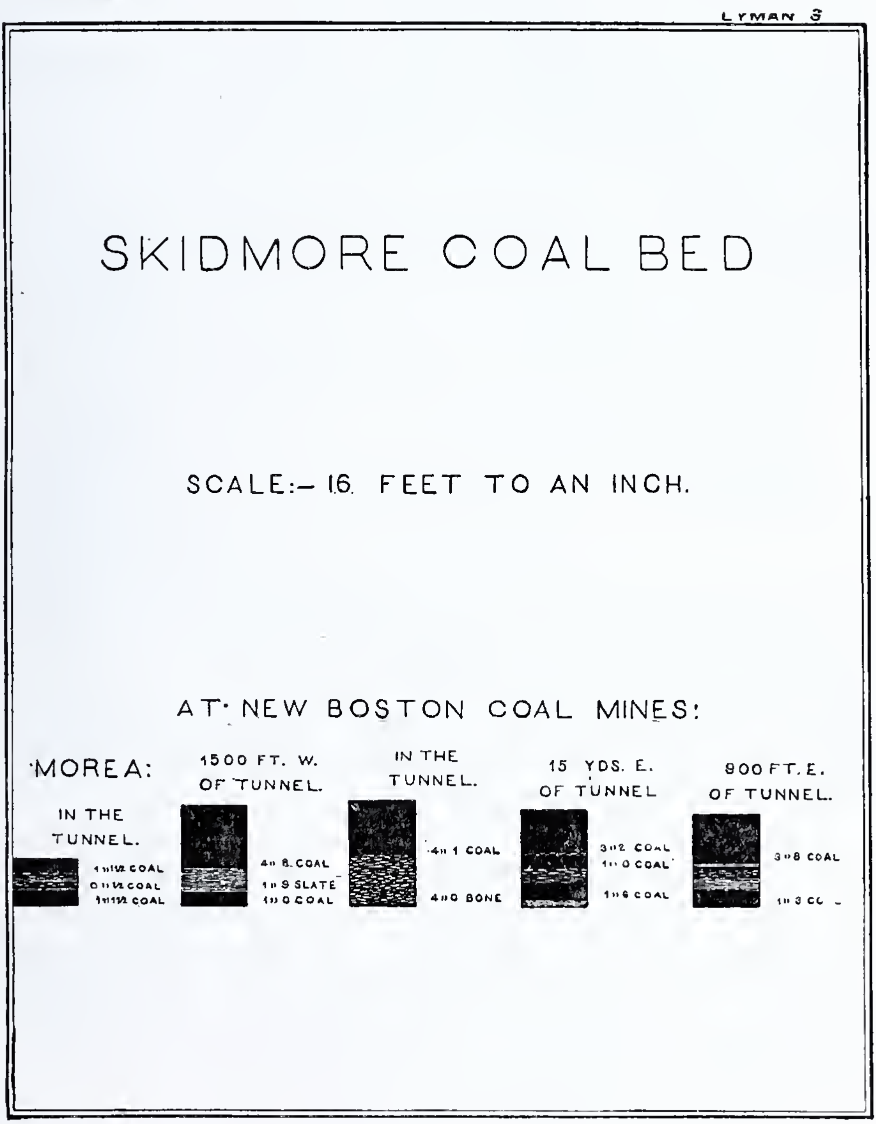
The amount in tons of coal, then, with the average thickness as already estimated for each lease, would be for the New Boston lease 2,275,000 tons, and for the Morea lease 4,690,000 tons, or in both together 6,965,000 tons.

At New Boston the bottom split had at our latest information already been worked through a space of about 90 acres bed surface, diminishing, then, the whole amount there by 1,240,000 tons, and leaving 1,035,000 tons of that split in the lease yet to work. Our information as to the extent of the workings is based on the mine maps up to the summer of 1886, made under Mr. P. W. Sheafer's direction, and some under-ground mapping by Mr. E. H. Lawall made previous to 21 September, 1888, eastward of the slopes and tunnel, and is represented in outline upon the map. The narrow strips, left in some places between the workings and the outcrops have been reckoned in as a part of the space spoiled by the workings. It is possible that some small portions of the pillars left in the workings may hereafter be recovered. It has not seemed necessary to undertake a more exact estimate of the amount worked to the present time, because an accurate survey of the under-ground workings is now under way. It has ap-

peared desirable nevertheless to give some idea of the amount worked out up to a couple of years ago.

Quality.—The coal of this bed is reckoned in general of excellent quality, and is considered the best of all at New Boston. The inferior, bony benches have already been indicated in the different sections and have been left uncounted in the estimate of the amount of workable coal; though some of them may perhaps not be altogether useless.

SKIDMORE BED.—*900 feet east of New Boston Tunnel.*



—In the New Boston mines at a point on the main gangway of the Skidmore bed at some 900 feet east of the tunnel my measurements gave the following section from above downward (see the drawing on page 69):—

Coal,	3′	8″
Slate,	0′	1″
Coal, the lower half rather bony,	1′	0″
Slate,	0′	11″
Coal,	1′	3″
	6′	11″

We have, here, then 5 feet 11 inches of coal within a total thickness of 6 feet 11 inches; but 6 inches of the coal is rather bony. The rest is good, though not equal to the Mammoth and Buck Mountain coals.

15 yards east of the New Boston Tunnel.—On the same gangway at about 15 yards east of the tunnel, my measurement of the Skidmore bed gave the following section from above downward (see the drawing on page 69):

Rock roof, "excellent."		
Coal with about 2 inches of slate at about 1 foot above the bottom,	4′	4″
Slate and coal mixed,	1′	0″
Coal,	1′	6″
Shale, about	0′	4″
Hard rock.		
	7′	2″

Here we have, then, 5 feet 8 inches of good coal within a total thickness of 6 feet 10 inches.

New Boston Tunnel.—The tunnel of the New Boston mines crosses the Skidmore bed, and according to the record at the mines yielded the following section from above downward (see the drawing on page 69):

Coal,	4′	1″
Clod, slate, dirt and bone mixed,	4′	0″
	8′	1″

There are, then, at that point 4 feet 1 inch of coal by itself, no good coal bench having been distinguished in the lower part.

1500 feet west of the New Boston Tunnel.—At the face

of the west gangway on the Skidmore bed in June, 1887, some 1500 feet west of the tunnel, my measurements gave the following section from above downward (see the drawing on page 69):

Coal,	4′	8″
Slate,	1′	9″
Coal,	1′	0″
	7′	5″

The coal here, then, is in all 5 feet 8 inches thick, within a total thickness of 7 feet 5 inches.

Morea.—The tunnel in the Morea mine crosses the Skidmore bed, and gave, according to our measurements, the following section from above downward (see the drawing on page 69):

Coal,	1′	1½″
Bone and coal,	0′	6″
Slate,	0′	2″
Bone,	0′	5″
Coal,	0′	0½″
Black slate,	0′	1½″
Coal,	1′	1½″
	3′	6″

Here, then, there are 2 feet 3½ inches of coal within the total thickness of 3 feet 6 inches,—scarcely a workable thickness at present.

Average Thickness.—The four sections of the Skidmore in the New Boston mines give an average thickness of 5 feet 4 inches of coal within an average total thickness of 6 feet 4 inches. The measurements, though few in number for a very good average, are pretty well scattered through a passably central portion of the whole extent of the bed in the New Boston lease, and the average obtained may therefore be considered as applying to the whole lease.

In the Morea lease the only measurement of the bed is the one in the tunnel with a thickness of 2 feet 3½ inches of coal, besides some bone and some coal and bone, within a total thickness of 3 feet 6 inches. It is very scanty information to serve as basis for an average of the whole neighborhood, but if we consider that the change in thickness is on the

whole uniform from New Boston westward through the Morea lease we shall find that the bed will have a thickness of 3 feet of coal about a quarter of a mile east of the Morea mine, say at our section line O P; and that the average for the part of the lease east of the line O P would be about 3 feet 8 inches of coal within a total thickness of about 4 feet 9 inches.

Quantity—In the New Boston lease, as shown by our map, the Skidmore bed underlies in basin shape 145 acres; or if flattened out, would cover 163 acres; making of course the same allowances as in the other beds for the sliding down hill of the outcrop more or less, say ten feet on the average, and for the failure of good sound coal to rise to the surface of the ground by a variable space, say ten feet again on the average.

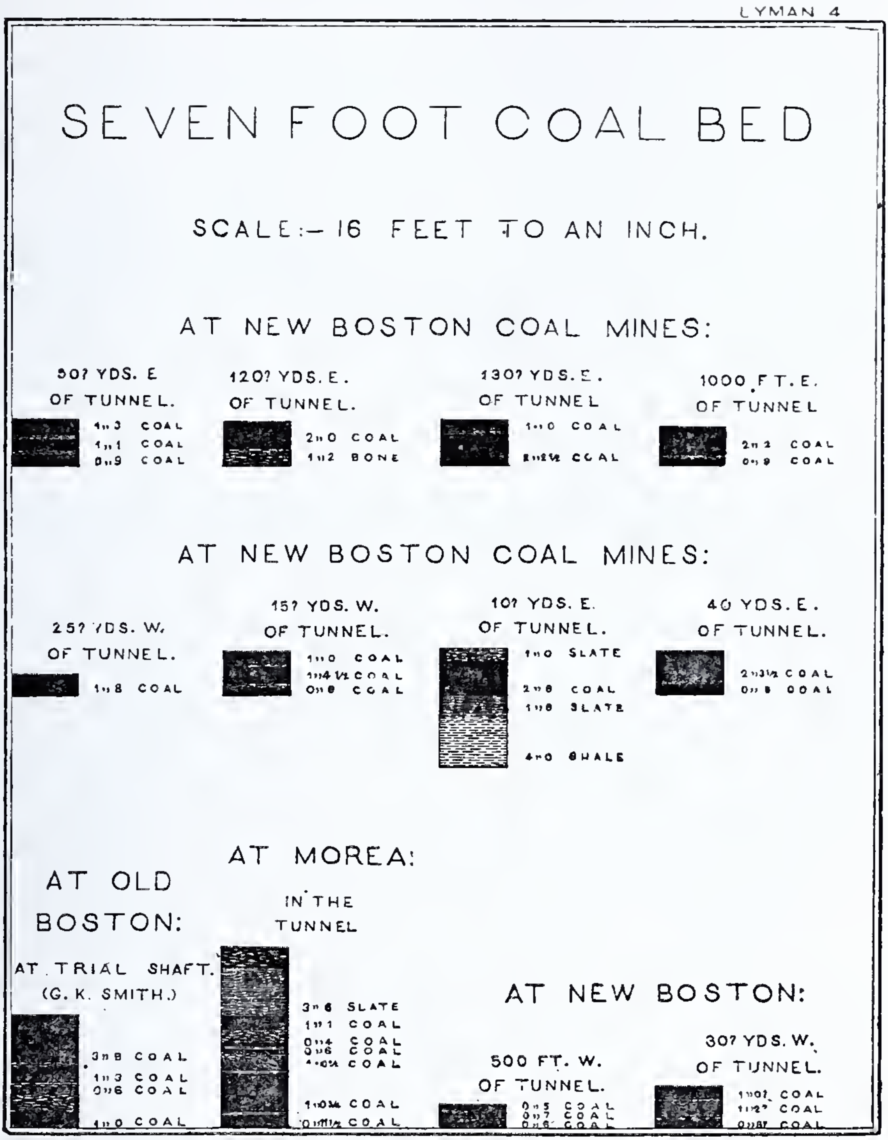
In like manner on the Morea lease, the workable part of the Skidmore bed, that is, as we have shown, the part that is east of our section line O P, underlies in basin shape 45 acres; or if flattened out, would cover 70 acres.

In tons, then, taking the average thickness of coal (not of total thickness of bed) for each lease as just given, we should have in the New Boston lease 1,580,000 tons of Skidmore coal; and in the Morea lease 340,000 tons of it workable; or in all 1,920,000 tons.

Of that amount, however, the workings up to the time of our latest information (that is, practically a couple of years ago, the same as with the bottom split of the Mammoth) had been worked out or spoiled through an extent of about 43 acres, measured on the surface of the bed; equivalent to 415,000 tons; leaving 1,165,000 tons yet to work in that lease.

Quality.—The quality of the Skidmore coal is not quite equal to the Mammoth and Buck Mountain coals; but is considered superior to the Seven-foot coal there.

SEVEN-FOOT BED.—*1000 feet east of New Boston Tunnel.*—In the New Boston mines at the face of the east gangway on the Seven-foot bed, about 1000 feet east of the tunnel, my measurements gave the following section (see the drawing on page 73):



Coal, with about 1 inch of slate at about 9 inches above the bottom, ... 3′ 0″

There are, then. 2 feet 11 inches of good coal within a total thickness of 3 feet. The coal is all shelly here.

130 yards east of the New Boston Tunnel.—On the same gangway at some 130 yards east of the tunnel, the Seven-foot bed, measured by me, gave the following section (see the drawing on page 62):

Coal, with $1\frac{1}{2}$ inches of bone at about 1 foot below the top . . . . 3′ 4″

We have here, then, 3 feet $2\frac{1}{2}$ inches of coal within a total thickness of 3 feet 4 inches. The bed was mined eastward to this point and abandoned about 1885, but working there had just been taken up again when the measurements were made.

120 yards east of the New Boston Tunnel.—On the same gangway, at some 120 yards east of the tunnel, my measurements gave the following section from above downward (see the drawing on page 73):

Coal, ...	2′	0″
Bone and coal mixed, ...	1′	2″
	3′	2″

Here we have, then, 2 feet of coal within the same total thickness, besides the 1 foot 2 inches of mixed bone and coal below.

50 yards east of the New Boston Tunnel.—On the same gangway, again, at some fifty yards east of the tunnel my measurement, except my estimate of the upper six inches, gave the following section from above downward (see the drawing on page 73):

Coal, about	1′	3″
Bone, about	0′	3″
Coal, about	1′	1″
Bone, about	0′	2″
Coal, about	0′	9″

This would give us, then, about 3 feet 1 inch of coal within a total thickness of about 3 feet 6 inches.

40 yards east of the New Boston Tunnel.—Still on the same gangway, at some forty yards east of the tunnel, the coal appeared to have the following section (see the drawing on page 73):

Coal, with about $2\frac{1}{2}$ inches of bone at some 9 inches above the bottom, ...	3′	3″

That gives, then, 3 feet and half an inch of coal within the total thickness of 3 feet 3 inches.

10 yards east of the New Boston Tunnel.—On the same gangway, perhaps ten yards east of the tunnel, the Seven-foot bed, by my measurement, gave the following section from above downward (see the drawing on page 73):

Black slate, about	1′	0′
Coal, without seam,	2′	6″
Black slate,	1′	6″
Dark brown slate, about	4′	0″
	9′	0″

We have here, then, 2 feet 6 inches of coal within the same total thickness.

At the New Boston Tunnel.—At the tunnel in the New Boston mines the Seven-foot bed is, according to the record of the horizontal distance across it, corrected for the dip, 2 feet 6 inches thick, without any seam in it mentioned. The roof is 13 inches of slate under 5 inches of shaly sandstone ("sandstone slate") and that under more than 20 feet of hard rock. The floor is seven inches of slate over 5 feet 10 inches of sandstone and shaly sandstone, with 10 inches of coal under that. This lower coal may be considered as the bottom split of the Seven-foot bed, since the two coals appear to be rather constant companions and the bottom one to be in some places the thicker, and the two are in places united or very near together.

15 yards west of the New Boston Tunnel.—On the gangway at the level of the old tunnel, in the New Boston mines and some 15 yards west of the tunnel, the Seven-foot bed, as measured by me, gave the following section from above downward (see the drawing on page 73):

Coal, about	1′	0″
Bone, about	0′	1½″
Coal, about	1′	4½″
Bone, about	0′	1″
Coal, about	0′	9″
	3′	4″

That gives, then, about 3 feet 1½ inches of coal within a total thickness of 3 feet 4 inches.

25 yards west of the New Boston Tunnel.—On the same gangway, at some 25 yards west of the tunnel, the same coal is pinched down to about 20 inches in thickness (see drawing on page 73).

30 yards west of the New Boston Tunnel.—On the same gangway, at some thirty yards west of the tunnel the bed has thickened up again to perhaps 3 feet, with probably the

same bony layers; leaving then, perhaps 2 feet 10 inches of coal (see drawing on page 73). But this was not measured.

1000 feet west of the New Boston Tunnel.—At the face (in June, 1887, but abandoned since April, 1886) of the same gangway, 540 feet west of the tunnel according to the mine map, my measurement gave the following section from above downward (see the drawing on page 73):

Coal, about	0′	5″
Bone, about	0′	$0\frac{1}{2}$″
Coal, about	0′	$7\frac{1}{2}$″
Bone, about	0′	1″
Coal, about	0′	6″
	1′	8″

Here there is, then, 1 foot $6\frac{1}{2}$ inches of coal within the total thickness of 1 foot 8 inches.

Morea.—In the mine at Morea, the tunnel crosses the Seven-foot bed and with my measurement gave the following section from above downward (see the drawing on page 73):

Hard fine grained sand rock (21′ 3″).		
Coal and dirt mixed,	1′	$7\frac{1}{2}$″
Black slate,	3′	6″
Coal, soft,	1′	1″
Slate and coal,	0′	11″
Coal,	0′	4″
Black slate,	0′	1″
Coal,	0′	6″
Bony coal,	0′	$1\frac{1}{2}$″
Coal,	1′	$0\frac{1}{2}$″
Black slate,	0′	$0\frac{3}{4}$″
Coal,	3′	$0\frac{3}{4}$″
Black slate,	0′	$0\frac{1}{2}$″
Coal,	0′	$11\frac{1}{2}$′
Streak of black dirt,	0′	0″
Blackish gray shale (3′ 4″).		
	13′	4″

Neglecting the uppermost coal bench as unworkable on account of its small thickness, its inferior quality and its distance from the rest of the bed, we have, then, 7 feet of coal within a total thickness of 8 feet $2\frac{1}{2}$ inches. The uppermost coal bench seems to correspond with the Seven-foot bed of New Boston, and the rest of the bed to what

we have called the bottom split of the Seven-foot in the New Boston tunnel section.

Old Boston.—At an old trial shaft by Mr. G. K. Smith, at Old Boston, according to his map and sections of January, 1885, the bed now known to be the Seven-foot bed had the following section from above downward (see the drawing on page 73):

Slate (perhaps 5′ 0″).		
Coal,	3′	9″
Bone,	0′	3″
Coal,	1′	3″
Bone,	0′	2″
Coal,	0′	6″
Bone,	1′	6″
Coal,	1′	0″
Slate (perhaps 4′ 6″).		
	8	5″

There is, then, a thickness of 6 feet 6 inches of coal within the total thickness of 8 feet 5 inches. The slate at the top and bottom of the section appears not to have been measured, but is indicated roughly and perhaps only as a conjecture in the drawing of the section, and very likely the full thickness was not exposed.

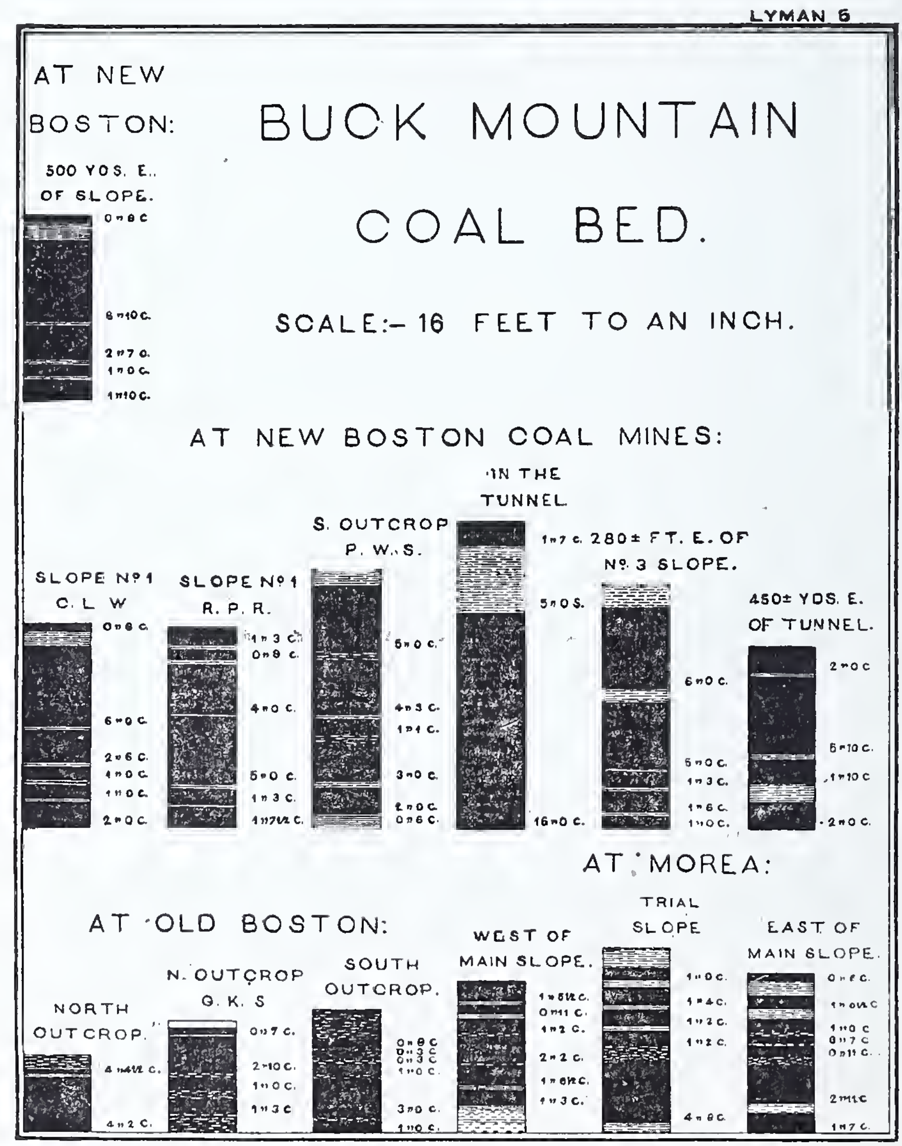
Average Thickness.—The average of all the measurements at New Boston would give the Seven-foot bed there a thickness of only 2 feet 7 inches within a total thickness of 2 feet 8 inches. As the quality there is also inferior, the bed appears not to be workable. Indeed the workings on it, of small extent, appear not to have been profitable, and were abandoned, both east and west, in April, 1886. Any work since that can clearly be merely for exploration, to see if possibly there be some workable spots.

At Morea, however, in the new mine, the Seven-foot bed is of very handsome thickness, and again at Old Boston is nearly as good. The bed at both places appears to correspond in place to the very thin wholly neglected bottom split of the Seven-foot seen in the New Boston tunnel. If we suppose that the coal and the total thickness of the bottom split thickens up uniformly on the whole from its 10 inches in the New Boston tunnel to its 7 feet in the

Morea tunnel, then decreasing in coal to its thickness at Old Boston, we shall have, for the average, 5 feet 1 inch in thickness of coal within a total thickness of 6 feet.

Quantity.--We cannot, then safely reckon on any workable coal from the Seven-foot bed in the New Boston lease.

But at Morea, the bed is workable, and its extent, as indicated by our map, is 129 acres in basin shape, or 189 acres on the surface of the bed, as it would be if spread out flat, making the same allowance as in the other beds for a loss of ten feet in width all along the outcrops.



The amount in tons, if we take the average thickness of the coal in the bed at five feet, according to the calculation just made, would be 1,720,000 tons.

Quality.—The coal of the Seven-foot bed at New Boston is not so good as the Skidmore coal, but the coal of the Morea Seven-foot bed (probably the lower split, not worked at New Boston) seems to be good.

BUCK MOUNTAIN COAL BED.—*500 yards east of slope at New Boston.*—On the north outcrop of the Buck Mountain bed at a point "500 yards east of slope" (probably slope No. 1) the bed measured, according to Mr. P. W. Sheafer, in a record of the State Survey, as follows, from above downward (see the drawing on page 78:

Coal,	0′	6″
Slate,	1′	4″
Coal,	6′	0″
Slate,	0′	2″
Coal,	2′	7″
Slate,	0′	2″
Coal,	1′	0″
Slate,	0′	3″
Coal,	1′	10″
	13′	10″

That would give, then, 11 feet 11 inches of coal within the total thickness of 13 feet 10 inches.

450 yards east of the New Boston Tunnel.—In the New Boston mines, at a point on the east gangway about 450 yards from the mouth of the tunnel, the bed, partly measured by myself, has the following section from above downward (see the drawing on page 78)):

Coal, called about	2′	0″
Slate, called	0′	$1\frac{1}{2}$″
Coal, called the Six-foot bench, say	5′	$9\frac{1}{2}$″
Slate, varying "from 1 in. to 6 or 9 in.", about	0′	3″
Coal, about	1′	10″
Slate,	1′	5″
Coal,	2′	0″
	13′	5″

There appears, then, to be 11 feet $7\frac{1}{2}$ inches of coal here within the total thickness of 13 feet 5 inches. It was difficult at this point for me to see all the measurements

myself, in so thick a bed not easily accessible, but they appeared to be pretty correct.

280 feet east of No. 3 slope.—At New Boston in the counter gangway (now become No. 4 slope) about 280 feet east of No. 3 slope and 254 feet up the slope from the main level, measurements made, the six lower ones by myself and the rest in my presence and apparently with tolerable accuracy, gave the following section of the same bed, from above downward (see the drawing on page 78):

Hard slate.		
Soft shales,	1′	6″
Coal, about	6′	0″
Slate,	1′	0″
Coal,	5′	0″
Slate,	0′	2″
Coal,	1′	3″
Slate,	0′	3″
Coal,	1′	6″
Slate,	0′	3″
Coal,	1	0″
	17″	11″

Here we have then, about 14 feet 9 inches of coal within a total thickness of 16 feet 5 inches.

New Boston Tunnel.—At the old tunnel at New Boston according to measurements of the upper part given in the record of the tunnel at the mine office, corrected by myself for the dip, and to Mr. P. W. Sheafer's statement of the thickness of the main coal in a section given by him to the State Geological Survey, the Buck Mountain bed has the following section from above downward (see the drawing on page 78):

Hard rock (70 feet).		
Coal,	1′	7″
Slate,	5′	0″
Coal,	16′	0″
	22′	7″

Apparently there would be here 16 feet of coal within the same total thickness, neglecting the upper coal bench as unworkable on account of its thinness and distance from the rest. But perhaps Mr. Sheafer did not intend to say that the whole of the 16 feet was free from slaty layers,

meaning only to give the full thickness of the bed without its subordinate details.

The upper coal bench, or rider, seems to be at some other points still more closely united to the main bed, and to be properly its top split.

New Boston south outcrop.—In a shaft on the outcrop on the south side of the basin at New Boston, according to a statement of Mr. P. W. Sheafer recorded by the State Geological Survey, the Buck Mountain bed had the following section from above downward (see the drawing on page 78):

Slate, ...	1′	0″
Coal, ...	5	0″
Slate, ...	0′	6″
Coal, ...	4′	3″
Slate, ...	0′	3″
Coal, ...	1′	1″
Slate and bone, ...	0′	6″
Coal, ...	3′	0″
Slate, ...	0′	6″
Coal, ...	2′	0″
Bone, ...	0′	3″
Coal, ...	0′	6″
Bone and slate, ...	0′	3″
	19′	1″

Here, then, there is a thickness of 15 feet 10 inches of coal within a total thickness of 17 feet 10 inches.

New Boston Slope No. 1, east gangway.—Mr. R. P. Rothwell gives in his report of 1870 a section measured by himself of the Buck Mountain bed at the face, in February, 1870, of the east gangway from slope No. 1, north side of the basin, as follows, from above downward (see the drawing on page 78):

Coal, ...	1′	3″
Slate, ...	0′	3″
Coal, ...	0	9″
Bone, ...	0′	3″
Coal, ...	4′	0″
Slate parting, about	0′	0″
Coal, ...	5′	0″
Bone, ...	0′	3″
Coal, ...	1′	3″
Slate, ...	0′	3″
Coal, ...	1′	7½″
	14′	10½

This gives, then, 13 feet $10\frac{1}{2}$ inches of coal within the total thickness of 14 feet $10\frac{1}{2}$ inches.

New Boston Slope No. 1.—His report also gives a section in the workings of the same No. 1 slope, north side of the basin, from measurements made by Mr. C. L. White, as follows, from above downward (see the drawing on page 78):

Coal,	0′	6
Slate,	1′	0
Coal,	6′	0
Slate,	0′	3′
Coal,	2′	6
Slate,	0′	3
Coal,	1	0′
Bone,	0	3′
Coal,	1′	0′′
Slate,	0′	3′
Coal,	2′	0
	15′	0

There is, then, here a thickness of 13 feet of coal within the total thickness of 15 feet.

Morea, east of Main Slope.—In the Morea mine at the face, 18th July, 1888, a few yards east of the main slope, measurements by Mr. A. P. Brown and myself gave the following section from above downward (see the drawing on page 78):

Coal, "runs like water,"	0′	6′′
Slate,	1′	1′′
Coal,	1′	$0\frac{1}{2}$′′
Slate,	0′	9′′
Coal,	1′	0′′
Bone,	0′	3′′
Coal,	0′	7′′
Dirt,	0′	$0\frac{1}{2}$′′
Coal,	0′	11′′
Bony coal, thinning upwards to 0′ $2\frac{1}{2}$′′ or less,	0′	$6\frac{1}{2}$′′
Coal,	2′	11′′
Dirt and slate mixed,	0′	8′′
Coal,	1′	7′′
Slate and dirt, exposed about 2′ 0′′.		
	11′	$10\frac{1}{2}$′′

Here, then, we have, neglecting the upper thin coal bench, and the bony coal, 8 feet and half an inch of coal within a total

thickness of 10 feet $3\frac{1}{2}$ inches. At a distance of 10 feet 9 inches above the top of the section there is a thin coal bed, 6 inches thick, called the "leader," that appears to correspond with the upper bench in the New Boston tunnel section and to be properly the top split of the Buck Mountain bed.

Morea Trial Slope.—When the first trial pit was dug at the Morea trial slope in the fall of 1887, Mr. Fritz, in charge there, obtained the following section of the bed, from above downward (see the drawing on page 78):

Yellow shaly sand rock,	7′	0″
Slate top,	1′	6″
Coal,	1′	0
Slate,	0′	6
Coal,	1′	4′
Slate,	0′	4′
Coal,	1′	2
Slate,	0′	4″
Coal,	1′	2″
Coal dirt,	1′	0″
Coal,	4′	9″
Slate bottom,	0′	9′
	20′	10″

That gives, then, without counting the coal dirt, 9 feet 5 inches of coal within a total thickness of 11 feet 7 inches.

Morea, west of Trial Slope.—In the Morea mine at the face of the west gangway, 18th July, 1888, perhaps a dozen yards west of the trial slope, Mr. Brown's and my measurements gave the following section from above downward (see the drawing on page 78):

Top slate.		
Coal,	1′	$5\frac{1}{2}$″
Black slate,	0′	$2\frac{1}{2}$″
Coal,	0′	11″
Black slate,	0′	2″
Coal,	1′	2″
Bone,	0′	$2\frac{1}{2}$″
Coal,	2′	2″
Bone,	0′	$0\frac{1}{2}$″
Coal,	1′	$6\frac{1}{2}$″
Slate,	0′	2′
Coal,	1′	3″
Black slate and dirt, about	2′	0″
	11′	$3\frac{1}{2}$″

We had, then, there 8 feet 6 inches of coal within a total thickness of 9 feet 3½ inches.

Old Boston south outcrop.—Mr. E. L. Bullock, under whose direction Mr. Fritz dug a trial shaft on the Buck Mountain outcrop at the south side of the basin opposite the Old Boston, or Glendower, old mine, gave the following section, of the bed there from above downward (see the drawing on page 78):

Slate and coal mixture,	2′	4″
Coal,	0′	9″
Bony,	0′	1″
Coal,	0′	3″
Bony,	0′	1′
Coal.	0′	3″
Bone,	0′	3″
Coal,	1′	0″
Bone,	0′	2″
Coal,	3′	0 ′
Bone,	0′	1″
Coal,	1′	0″
Soft fire clay.		
	9′	3″

There is, then, here a thickness of 6 feet 3 inches of coal in a total thickness of 6 feet 11 inches. A large part of the coal here is much divided up by bony layers.

Old Boston old trial pit.—Just north of the old Glendower mine at Old Boston, an old trial pit, according to Mr. G. K. Smith, gave the following section from above downward (see the drawing on page 71):

Rock,	0′	6″
Coal,	0′	7″
Slate,	0′	1″
Coal,	2′	10″
Bone,	0′	2″
Coal,	1′	0″
Bone and slate,	0′	6″
Coal,	1′	3″
Bone and slate,	1′	5″
	8′	4″

That would give, then, here 5 feet 8 inches of coal within a total thickness of 6 feet 5 inches.

Mr. G. K. Smith's drawing represents the space of 10 feet 6 inches above the section just given as filled with

slate, upon which (at a distance, then, of 11 feet above the Buck Mountain bed) there lies a coal bed 2 feet thick. This small bed corresponds closely to the "Leader" coal in the tunnel section at Morea, and like that may be regarded as the top split of the Buck Mountain bed.

Old Boston new trial pit.—A trial pit dug in the fall of 1887 ten feet southwesterly from the old one just mentioned, gave by my measurement the following section from above downward (see the drawing on page 78):

Soft dark gray, and the lower 6 inches black, shales	2′	4″
Coal and slate mixed, ...	1′	1″
Coal, good, soft on the outcrop, ...	0′	$4\frac{1}{2}$″
Gray clay, ...	0′	$0\frac{1}{4}$″
Coal, hard and good, without slate, ...	4′	2″
Gray shales, ...	1′	0″
	8′	$11\frac{3}{4}$″

There is here, then, a thickness of 4 feet $6\frac{1}{2}$ inches of coal within a total thickness of only a quarter of an inch more (4′ $6\frac{3}{4}$″).

Average thickness.—The seven New Boston sections give an average of 13 feet 10 inches of coal within a total thickness of 15 feet 4 inches, and that may be taken as the average for the New Boston lease, since we have no better information on the subject.

The three Morea sections give an average of 8 feet of coal within a total thickness of 10 feet 5 inches. The three Old Boston sections give an average of 5 feet 6 inches of coal within a total thickness of 5 feet $11\frac{1}{2}$ inches. If we suppose the bed to diminish uniformly in thickness from the average at the New Boston mines to that of the Morea mines and thence to Old Boston, we shall find the average thickness for the lease to be 9 feet 7 inches of coal within a total thickness of 11 feet. To be sure, the information is too scanty for a very trustworthy average.

Quantity.—Our map shows the Buck Mountain bed to underlie in basin shape 273 acres of the New Boston lease, or if spread out flat to have a surface there of 320 acres, making, of course the same allowance in each case of ten feet subtracted all along the outcrops, as in the measurement for the other beds.

In like manner, in the Morea lease, it underlies in basin shape 170 acres, or would, if flattened out, cover 248 acres.

In tons, then, the amount would be, for the New Boston lease, with the average thickness of coal (not total thickness) just accepted, 8,050,000 tons, and for the Morea lease, in the same way, 4,320,000 tons, or in all 12,370,000 tons.

The bed has, however, at New Boston, according to our latest information (the same as for the Mammoth and Skidmore beds, practically previous to a couple of years ago), been worked out or spoiled, through a space of about 190 acres of the bed, equivalent to about 4,780,000 tons of coal spoiled, leaving in that lease at that time about 3,270,000 tons yet to mine.

Quality.—The quality is reckoned at New Boston, where it has been so extensively mined, as very good, and about equal to the Mammoth coal. The quality is probably about the same on the Morea lease, except that the smaller subdivision with slate or bone seams will add to the difficulty of sending clean coal to market.

Spring coal bed.—About 35 feet below the Buck Mountain bed there is a thin coal bed, found in trial pits at Old Boston, and according to Mr. G. K. Smith's map and sections of January, 1855, with the following section from above downward, at his old pit there:

Sandstone.		
Coal,	1′	0″
Bone,	0′	2″
Coal,	1′	0″
Slate.		
	2′	2″

This would yield, then, 2 feet of coal within the total thickness of 2 feet 2 inches.

A new trial pit on the same outcrop, at 18 feet westerly from that one gave by my measurement, in October, 1887, the following section, from above downward:

Gray coarse hard sand rock with pea pebbles.		
Light brown soft shaly sand rock, about	0	6″
Coal, hard and good, bright,	1′	6″
Gray shales,	0′	6″
	2′	6″

Here there are only 1 foot 6 inches of coal within the same total thickness. A couple of feet above the bottom of the hole the coal bed had measured at least 6 inches more, owing to the spreading out near the broken outcrop with the bed standing nearly vertical.

The same bed has evidently been opened by a very old trial pit further west on the same outcrop near the western edge of the tract. But elsewhere it does not seem to have been discovered and there is no record of its existence near New Boston.

It is clear that the coal is too thin to work with profit at present. But it has seemed worth while to map its outcrop; because it is marked on the ground by a line of strong springs both near Morea and near New Boston, and in looking for water a knowledge of the place of the outcrop may be a useful guide.

LYKENS VALLEY COAL BED.—The Lykens Valley coal bed has been bored through by the new artesian well at New Boston, and appears to have a thickness there of about 2 feet 7 inches, after correcting the vertical distance through it for the dip. It seems also to have had about the same thickness in the well of the New Boston village street. It is also said to have had a thickness of about two feet and a half at the very old trial pit a quarter of a mile northwest of the Morea station. At the Pennsylvania R. R. cutting near the southwest corner of the tract the coal measured about 1 foot 8 inches. There is no proof, then, that the bed anywhere upon either lease comes up to the workable thickness of three feet.

Nevertheless it is reported to have had a thickness of about four feet of coal besides four feet of slate at the old trial pits near the cemetery just outside the northern edge of the New Boston lease near its northeast corner. Although such traditions are only too apt to be exaggerated favorably, it might be well to make at a future time some further trial pits inside the tract in that neighborhood along the outcrop, indicated approximately on our map, in order to ascertain the merits of the bed with certainty. For the

quality of its coal is reputed to be very excellent, and even a comparatively thin bed of it might be considered workable.

5. *Summary of the Workable Coal.*

To sum up, then, we have the number of acres of each workable coal bed in each lease and the corresponding number of tons, as set forth in the two following tables:

Acres of Workable Coal.

	New Boston Lease.				*Morea Lease.*		*Both Leases.*		
	In all.		*Mined.*	*Unmined.*	*In all.*		*In all.*		*Unmined.*
	Basin.	*Flat.*	*Flat.*	*Flat.*	*Basin.*	*Flat.*	*Basin.*	*Flat.*	*Flat.*
Mammoth top split	34	38	0	38	29	37	61	75	75
Mammoth middle split	78	95	0	95	73	90	151	185	185
Mammoth bottom split........	113	134	90	44	89	129	202	263	173
Skidmore bed..................	145	163	43	120	45	70	190	233	190
Seven-foot bed	0	0	0	0	129	189	129	189	189
Buck Mountain bed	273	320	190	130	170	248	443	568	378

Tons of Workable Coal.

	New Boston Lease.			*Morea*	*Both Leases.*	
	Mined.	*Unmined.*	*In all.*	*Lease.*	*In all.*	*Unmined.*
Mammoth top split	0	725,000	725,000	705,000	1,430,000	1,430,000
Mammoth middle split,	0	520,000	520,000	735,000	1,255,000	1,255,000
Mammoth bottom split,	1,240,000	1,035,000	2,275,000	4,690,000	6,965,000	5,725,000
Skidmore bed..........	415,000	1,165,000	1 580,000	340,000	1,920,000	1,505,000
Seven-foot bed	0	0	0	1,720,000	1,720,000	1,720,000
Buck Mountain bed....	4,780,000	3,270,000	8,050,000	4,320.000	12,370,000	7,590,000
	6,435,000	6,715,000	13,150,000	12,510,000	25,660,000	19,225,000

The ton number in each case is given as the nearest round five thousand; and even that may seem to have an exaggerated appearance of precision, considering how very imperfect our knowledge necessarily is of the average thickness of the coal beds. The estimate of the amount of mined, or spoiled, coal has been made with less minute care, because it has not seemed worth while with the poor information at hand, so long out of date, in a rapidly advancing colliery.

The average thickness of the coal in each bed, used in computing the foregoing table of tons, and the average total thickness of the part of each bed that just includes the coal so reckoned are based on information that is in all cases scanty, and in regard to the two upper splits of the Mammoth bed, especially imperfect. The results, however, are

the best at present attainable, and are given in the following table:

	New Boston.		*Morea.*	
	Coal.	*Total.*	*Coal.*	*Total.*
Mammoth top split, ...	10′ 6″	13′ 3″	10′ 6″	13′ 3″
Mammoth middle split, ...	3′ 0″	3′ 0″	4′ 6″	5′ 5″
Mammoth bottom split, ...	9′ 4″	10′ 7″	20′ 0″	25′ 0″
Skidmore bed, ...	5′ 4″	6′ 4″	3′ 8″	4′ 9″
Seven-foot bed, ...	2′ 7″	2′ 8″	5′ 1″	6′ 0″
Buck Mountain, ...	13′ 10″	15′ 4″	9′ 7″	11′ 0″
	44′ 7″	51′ 2″	53′ 4″	65′ 5″

As regards quality, the coal of the bottom split of the Mammoth bed is, at New Boston, considered the best of all they have worked there; but the Buck Mountain coal is called about equally good. The Skidmore coal is found somewhat inferior; and the Seven-foot there is the least satisfactory of all. The Seven-foot coal at Morea appears to be quite another bench, and seems to be of good quality. Nothing definite is known of the quality of the two upper splits of the Mammoth on the tract. No assays have been made of any of the coals.

6. *Shipment.*

The breaker of the New Boston mines is connected by a branch track with the Pennsylvania railroad, and is by that line 104½ miles from Philadelphia. The breaker is also connected by another branch with the Lehigh Valley railroad, and by that line is 126½ miles from Philadelphia and 162½ miles from New York city.

The Morea breaker has likewise branches to both of those railroads; and by the Pennsylvania line is 103 miles from Philadelphia, and by the Lehigh Valley line is 127¾ miles from Philadelphia, and 163¾ miles from New York city.

7. *Maps and Sections.*

There are several groups of trial pits and borings on the tract, and in many cases, particularly with the borings, the holes are so near together as to be somewhat difficultly distinguished upon our large map. We have, therefore, made the following smaller maps [not printed] of the different groups on the four times larger scale of one

hundred feet to an inch. Some of the trial pits are 35 years or more old, and many of them more than 25 years old. A few were dug by us near old Boston in 1887, and a number of others by the present lessees of the Morea lease in 1887 and 1888. But especially a great number of short bore holes, without any digging into the loose superficial wash, were put down by them in those years. There are no records of most of the older pits, except in some cases the fact whether coal was found or not; and that fact can generally be ascertained on the ground by searching for bits of coal that have been thrown out. In many of the recent bore holes posts were left standing with a rough record of the results of the boring. These records were copied by us and seem, on the whole, to be the most trustworthy information about the holes. Mr. E. L. Bullock, who had the superintendence of those explorations, has been so kind as to have records of their results sent to us, such records as had been preserved in his office. In some of the groups, however, there seems to be a little discrepancy between the office records and those on the posts, and in one or two cases, owing to a misunderstanding of the identity of the group, the record was misapplied in sending to us. This last error happened in regard to the group by the canal rock cutting near the southwest corner of the tract, and was not discovered until after the photo-lithographing of the large map. In consequence the outcrop of the Buck Mountain coal bed was there marked a few feet, perhaps ten feet, further south than had otherwise seemed to be its right place. The results of the borings near the Morea railroad station seemed also to require the coal outcrops to be a few feet (perhaps twenty) further south than otherwise seemed probable; but, as we had no other better information from the posts there, the outcrop was marked in that southern position.

It has seemed desirable to preserve as far as possible by these small maps the record of all the trials that have been made. And if a careful and complete record of all the numerous holes from the beginning had been kept, the understanding of the geology of the tract would have been much facilitated.

The large map of the tract, on a scale of 400 feet to an inch, dated 12 January, 1889, has been photo-lithographed from our original map on a scale of 300 feet to an inch. The original was upon plotting paper cross-barred with blue lines, some traces of which, contrary to expectation, are still visible in the photo-lithograph. The surveying was done almost wholly in the summer of 1888, with a transit compass, and the position of each station was computed by the system of latitudes and departures. The leveling of the stations, with very few exceptions, was done with the spirit level; and for those few others with the vertical circle. Upon the map sheet there are eleven geological sections across the basin, which not only show our view of the structure, but were most important aids in studying it out, and in enabling the outcrops and the coal bed contour lines to be drawn. The blank portions of the sections are occupied by rocks not observed by us anywhere in the survey, but could be filled approximately from the information given by the east Mahanoy tunnel section, near as it is.

Our labors in the field ended 17 October, 1888, and we have received no information, even by letter, about the rapidly advancing work on either lease later than the 10th of November, 1888.

My two intelligent and careful assistants, Messrs. Amos P. Brown and J. S. Elverson, have not only by their industry much hastened the completion of the work, but have by their observant criticism from point to point doubtless added to the accuracy of the result. Even "two heads are better than one."

BENJ. SMITH LYMAN.

PHILADELPHIA, *14 February, 1889.*

The State Line Serpentine and Associated Rocks.

BY FREDERICK D. CHESTER.

These rocks, forming the subject of the present paper, cover that large belt of country in the south-western portion of Chester county, Penna., known as the "barrens." The area under consideration has a length of about seventeen miles; beginning with Little Elk creek it extends along the Maryland line crossing the Octoraro creek into Lancaster county. The average width of the belt is about one mile; its eastern portion between the Little Elk and the Philadelphia and Baltimore Central R. R. lies well north of the Maryland line, while to the west the southern line is somewhat below but approaching the same boundary. In recalling the exact form and position of this area of serpentine, the reader is referred to the geological map of Chester county accompanying Report C^4 of the Pennsylvania survey.

When the writer, in the autumn of 1886, made an excursion for the examination of this interesting area, he had already had the opportunity of becoming well acquainted with certain coarse-grained uralitic hypersthene rocks in Delaware, which in some cases presented such close analogies in the field with certain of the fresher forms here met with as to make the subject an especially inviting one; and at once the thought presented itself that the various forms of rhombic pyroxene rock so extensively developed in Delaware were more widely distributed than supposed, and furthermore possibly closely related with many of the important serpentine areas of south-eastern Pennsylvania.

How far this is true it is the intention of the writer to investigate; at present we will content ourselves with a study of but one of these numerous localities.

After an examination of the thin sections and accompanying hand specimens collected from various portions of the

belt, one must observe two directions of variation as dominant. The first is towards the production of the common serpentine, in which a non-feldspathic bronzite-diallage rock is the original material; and the second is towards the production of a greenish hornblende rock, both massive and schistose in character, and quite similar to the so-called *gabbro-diorites* of Delaware and Maryland. This last rock, styled by Dr. Persifor Frazer in one case a hornblende gneiss, and in another a "trap," the use of the terms evidently being largely controlled by the structural habit of the rock, whether schistose or massive, is not apparently regarded by him as having any genetic relationship with the serpentine.* Our present studies, however, with the microscope, reveal clearly that this is not altogether the case, but rather that many, at least, of these black hornblende rocks, represent one extreme in two diverging directions of variation.

The truth is, we have in the eastern portion of this serpentine belt two hornblende rocks, which, in the field, could easily be confounded, but which petrographically are quite distinct.

These are, first, a pyroxene-hornblende rock, in which the hornblende is secondary, and in which quartz is not associated with the basic feldspar; and second, on the outer verge of the belt and within the mica schists, a quartz bearing hornblende gneiss, in which all the constituents appear to be original.

It is those hornblende rocks, genetically connected with the serpentines, with which we are particularly interested at this time.

In a general view of the rocks of this belt we must understand that all are highly modified types in which the original minerals have undergone alteration into secondary products. Nevertheless, in the less highly changed forms we are enabled to see what was the character of the original mother rock from which these secondary types have been derived. This in the majority of cases we find to be a coarsely crystallized massive rock, consisting mainly of a

*Report on Chester county, C4, Second Geological Survey of Penna., p. 91.

rhombic pyroxene more nearly allied to *bronzite*, with which is associated a less amount of monoclinic pyroxene, probably *diallage*.

In the typical forms the rock contains none or but a trace of feldspar; yet in the dark green hornblendic varieties, to which we have just referred, a basic plagioclase appears in considerable amount, and is associated with the original rhombic and monoclinic pyroxene; both of which in all cases have undergone alteration into the fibrous hornblende. It is, of course, the pyroxene rock, free from feldspar, which is the mother rock of the serpentines; the intermediate stage in the production of serpentine being the alteration of both of the pyroxene members into hornblende aggregates, which in turn give rise to the final products serpentine and talc.

The Bronzite-Diallage Rock.—This is a massive greenish gray rock of a somewhat fibrous silky character, in whose finely crystallized ground mass elongated prismatic individuals of bronzite are porphyritically developed. The density of the rick is high, one determination with a typical specimen giving a specific gravity of 2.98.

Bronzite is the principal mineral, and can be recognized in a number of the coarser hand specimens by its dark greenish gray or brown color, submetallic lustre, and by its eminent rectangular cleavage, parallel to the prismatic face (∞ P). A number of cleavage leaflets detached with a penknife were examined. In ordinary light the sections were of a light greenish gray color. With the polarizer the pleochroism was generally feeble: the thicker prismatic sections showing a light green tinge for rays vibrating parallel to the vertical axis, and a yellow color for rays transverse to the same. The absorbtion of the c. ray was evidently greater than for either of the transverse rays.

The extinction is in all cases parallel, and the polarization colors of the thinnest sections rather brilliant. The specific gravity of a number of these fragments, which after microscopic examination were found to be clean, was determined by means of the Klein solution, and found to be 3.14.

In the thin sections, the bronzite occurs in elongated,

prismatic columns, and is entirely colorless and therefore devoid of all pleochroism. The mineral contains numerous dust-like inclusions of a magnetic iron ore. All these columns extinguish parallel to the longest development. Several cross sections were found which showed the double rectangular prismatic cleavage, besides a separation parallel to one of the pinacoids. These, when examined with concentrated polarized light, showed a bisectrix nearly in the center of the field. From these statements there can be no doubt of the rhombic nature of the mineral in question.

The bronzite of one of these rocks was separated in the usual way by means of the Klein solution. The impure bronzite, thus obtained, was treated again in a solution in which hornblende floated, but in which a specimen of the bronzite of this rock readily sank. A chemical examination of this separated mineral showed that silica, magnesia and iron existed in predominating amount, with very slight reactions for alumina and lime. This proves that the mineral is a magnesian silicate, either enstatite or bronzite. A quantitative determination (of the iron) gives 12.33 per cent. calculated as ferrus oxide, a result which may be somewhat high, owing to the included magnetic dust, so common to all the enstatite as to make its separation impossible.

Tschermak* designates those varieties of rhombic pyroxene which contain from 5 to 15 per cent. of ferrus oxide as bronzite, those with less, enstatite, those with more, hypersthene: upon this ground we feel warranted in calling this rhombic pyroxene a lower member of the bronzite group, rather than an enstatite. It is possible, however, that this rhombic pyroxene may vary as regards the proportion of iron, causing the mineral to range in position between a more ferriferous enstatite and a less ferriferous bronzite. This idea seems to be fully confirmed after a study of certain analyses of these rhombic pyroxenes made by the Second Pennsylvania Survey. All the elongated columns of bronzite show the cross-fissures commonly characteristic of this mineral; there seems to be, however, no marked tendency to decomposition along the fissures into any substance of the nature of

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*Tschermak Lehrbuch der Mineralogie, p. 436.

bastite. The alteration, on the other hand, is of a different character, the bronzite in all cases showing every stage of replacement by colorless or pale green fibres of either tremolite or actinolite. These fibres which in the alteration of bronzite are generally colorless, are developed externally and internally along the cleavage fissures. They polarize most brilliantly when the section is turned to the position of extinction of the bronzite, and extend, as a rule, the entire length of the original columns, with arrangement parallel to the vertical axis. Very commonly fibres of tremolite originating within the bronzite cause a brush-like fringing of one end of the same, with perhaps a simultaneous destruction of either side. In the final stage of alteration obscurely defined columns, which between crossed nicols prove to be bundles of interlacing fibres, hold in their centers ragged remnants of the original pyroxene. So clear is this process of alteration that all stages in the change up to the complete replacement of the bronzite by fibrous matter can be observed in a single slide. The alteration of rhombic pyroxene into hornblende aggregate is by no means uncommon.

Hypersthene in many uralitic gabbros frequently becomes surounded by fringes of tremolite fibres, with the separation of its iron in the form of magnetite. Changes of this character have been fully described and figured by Dr. G. H. Williams* in the Baltimore gabbros, and later, similar changes were discovered by the present writer† in the Delaware rocks.

Similarly, Dr. Williams at Baltimore found certain bronzite rocks which showed an alteration into colorless or light green hornblende.

Interesting examples of the alteration of bronzite into asbestiform tremolite are found in certain chromite bearing serpentines in the eastern part of the belt. Porphyritically developed within the serpentine are found white fibrous columns, which, by teasing out with a small knife blade,

* Bulletin U. S. Geol. Survey No. 28. The Gabbros and Associated Hornblende Rocks in the Neighborhood of Baltimore.

† Bulletin No. — U. S. Geol. Survey. The Gabbros and Associated Rocks in Delaware.

are found to consist of parallel white fibres or threads of asbestos. Thin sections of this same rock show these asbestiform columns, in the centers of which are always found ragged elongated cores of rhombic pyroxene. This alteration is accompanied with the separation of only a trace of magnetic iron, less than is generally the case in the more highly ferruginous bronzite or hypersthene.

The alteration of any rhombic pyroxene into hornblende is not easy to explain from the chemical side.

In the alteration of hypersthene into tremolite in many hypersthene gabbros a satisfactory explanation is not so difficult, since the borders of tremolite commonly are found at the contact between the hypersthene and the adjacent grains of lime-bearing feldspar.

In these non-feldspathic bronzite rocks, however, the case is different and less easy to explain. The only clue to the matter, the writer would venture to suggest, seems to lie in the presence, as a constant constituent of these rocks, of a dark green apparently original hornblende.

This mineral occurs in such compact, clearly defined grains, grains on which definite crystalline faces are found, that it stands in strong contrast to the secondary and lighter variety.

The pleochroism of this hornblende is strong: cross sections show well the double prismatic cleavage, and give the colors of the $\mathfrak{a}$ and $\mathfrak{b}$ rays. The pleochroism arrangement is therefore as usual. $\mathfrak{a}$=pale yellow; $\mathfrak{b}$=yellowish green; $\mathfrak{c}$=bluish.

Sections which, from the pleochroism are approximately parallel to the clinopinacoid, give, with reference to the vertical axis, angles of extinction near 15°. Sections which extinguish parallel give with converged light to the side appearance of an optic axis. In some cases this hornblende is rich in inclusions of a yellow mineral, which, from their acute wedge-shaped forms and strong refractive index, appear to be *titanite*.

The relation of this primary hornblende to the partly altered bronzite is interesting. The larger grains of this green hornblende commonly contain included prismatic

individuals of bronzite, while again the same elongated columns of rhombic pyroxene penetrate for greater or less depths into the hornblende substance.

The effect of the alteration of the bronzite under these relations is to cause a marked disintegration of the hornblende.

In one section at hand, grains of hornblende five or six millimeters across, which contained originally included prisms of bronzite, have become so affected by the alteration of the latter as to appear as isolated areas in a mass of confusedly arranged, brilliantly polarizing fibres of tremolite. That all these isolated areas are crystalographically a unit is shown by the position of the cleavage lines, and by their absolutely uniform extinction.

The very ragged character of these isolated remnants of hornblende can leave little doubt, in this case at least, that in the production of these tremolitic aggregates a reaction took place between the original green hornblende and the included bronzite, causing an entire destruction of the latter, and a partial destruction of the former. Furthermore, bronzite and green hornblende are frequently intergrown with one another, while again the two minerals may be placed in definite twining position to each other. In either case the effect of the alteration into tremolite is to destroy both original substances. The intimate association, in all cases, of ragged grains of compact green hornblende with secondary matter is strongly suggestive of the idea that, as a supplier of lime, this original hornblende may, in these rocks, have taken the same part that the feldspar did in the Baltimore gabbros just referred to.

Another frequent, if not constant constituent of these rocks is a light green, unpleochroic mineral which gives angles of extinction from 0° to nearly 38°, and answers closely to *diallage*.

The cleavage is eminent parallel to the prismatic face (∞P), and to the orthopinacoid ($\infty P \infty$). Sections of this mineral which extinguish rays vibrating parallel to the vertical cleavage fissures, and therefore sections in the zone $\infty P \bar{\infty}$: OP show, with converged light, the appearance of an optic axis near the center of the field.

The diallage exhibits the same alterations already adduced

into aggregates of light green to colorless amphibole. This change takes place first externally, whereby the borders take on a most ragged and disintegrated appearance, as seen between crossed nicols, the brilliantly polarizing fibres interlacing one another, but with a general arrangement parallel to the vertical axis. Thus, by this gradual replacement from the outside, the original mineral disappears, or remains as a ragged remnant in the center of the mass of secondary fibrous amphibole. Second, we observe an internal change, fibres of brilliantly polarizing amphibole developing within the body of the mineral, chiefly along and parallel to the cleavage fissures.

As already mentioned, feldspar does not exist as a constituent of the enstatite rock, but, judging from the character of certain extreme types, it is probable that in the large mass it occurs in small but variable amount, whereby these rocks graduate into true bronzite gabbros, which, in their altered forms, we frequently find within this area.

Olivine is found in these rocks in but few instances, although its more frequent occurrence in the serpentine would indicate a more extensive distribution through the mother rock than the sections at hand reveal. The mineral can be easily recognized in small rounded grains, rarely with crystalline outline, by its marked relief and brilliant polarization colors. In the few instances in which it occurs it is quite fresh, and shows no alteration along the lines of fissures, into serpentine, such as is observed in the olivine of the serpentines.

Minute grains and dust-like particles of a magnetic iron ore occur in the rock as a constant but small constituent. Portions of this, extracted with the magnet, gave no notable reaction for titanian or chromian.

Enstatite Gabbro and Gabbro-Diorite.—More particularly at the eastern end of the State line serpentine belt there is found a dark green to black rock which is massive, or obscurely foliated. In the field the rock presents strong analogies with the gabbro-diorites of Delaware. Originally the rock consisted of a mixture of plagioclase, diallage, bronzite and some original (?) green hornblende.

In all cases the pyroxene elements have undergone alteration into light green or colorless hornblende aggregates, whence there results the so-called gabbro-diorite, a rock which structurally and macroscopically would be classed as a true diorite, but which to microscopic examination proves itself to be secondary, and not entirely free from some original pyroxene.

The processes of pseudomorphism or paramorphism observed in these rocks are interesting. It must be noticed that the typical and predominating method of alteration of the rhombic pyroxene is first into aggregates of colorless hornblende, probably tremolite, while these in turn pass into serpentine, and perhaps into talc.

In the bronzite gabbro-diorite, however, the second step in the process is different. Here the colorless tremolite shows a tendency to become green and compact externally, presenting an appearance under the microscope very similar to that observed in other gabbros. In one case under observation, a core of tremolite needles is surrounded by a border of grass green hornblende, which varies from strongly to weakly pleochroic.

In other more advanced stages of this change we find areas of compact green hornblende in the centers of which exist irregular cores of green hornblende aggregates which in ordinary light are unindividualized, but which between crossed nicols stand out most brilliantly. Thus the final product of the bronzite is a rather compact green hornblende, a change which is identical with that observed in the rhombic pyroxene of Delaware. The diallage of these rocks, which is identical with that already described, shows a similar alteration into light green, feebly pleochroic hornblende needles, or again, into needles of a darker color and notably pleochroic.

The feldspar of these rocks is apparently all triclinic, and shows the usual twining structure; the angles of extinction are all high, indicating one of the basic series. This observation was confirmed by the examination of cleavage sections detached with a penknife, including those parallel to the basal plane (P), and to the macropinacoid

(M); here the angles of extinction with reference to the edge P : M were sufficiently high to indicate a feldspar approaching *anorthite*. The specific gravity of a number of these fragments was determined with specific gravity solution and found to be 2.73.

The feldspar of these rocks is unusually full of colorless elongated inclusions which are very similar in appearance to those found in certain anorthite gabbro-diorites of Delaware, already described and figured by the writer.*

They include both long and short prisms with either rectangular or pyramidal terminations: the extinction of the larger examples is distinct from the enclosing matter, and frequently at rather high angles. The feldspar partakes of the ragged disintegrated character common to all the constituents of this rock. This is due to the disintegration of adjacent individuals of pyroxene and of those included within the latter mineral. In short, the feldspar and bronzite of these gabbros present the same relations to each other as exists between the rhombic pyroxene and the hornblende in the non-feldspathic rock.

Massive Asbestiform Rocks.—In traveling over the serpentine belt, one's attention is occasionally attracted to certain coarse massive boulders which have weathered to a light brown. These on close examination are found to consist entirely of an asbestiform tremolite, which, in places, graduates into a fleecy asbestos. Associated with these rocks are equally massive boulders consisting of a brownish mineral in large grains. A section of this rock proves that the mineral in question is, even in thin section, strongly pleochroic and identical with the hypersthene of the Delaware rocks. The hypersthene has undergone an alteration into tremolite, as seen in the section, with the separation of much iron in the form of magnetite.

The Serpentine.—These rocks vary greatly in appearance. Their color changes from a light green to a yellow,

*The Gabbros and Associated Rocks in Del. Bulletin — U. S. Geol. Survey.

when dry. Many portions of the belt exhibit valuable deposits of chromite sand, occurring generally along the courses of the streams. This sand has been derived from the weathering, and transportation by water of the serpentine detritus which contains granules of the ore, easily seen with the naked eye. The most important conclusion derived from a study of the serpentines proper is that they are all apparently derivative in character from the original pyroxene rock already described, and therefore, they must belong to that important class of metamorphosed eruptive "traps" rather than to the class of altered sediments. The most superficial observer cannot fail to notice the frequent association with the serpentine of talcose and asbestiform products. These occurrences are not without their significance, as our microscopic studies show.

All the serpentines of this belt so far as our observations have gone are rich in the usual tremolite aggregates, which, in turn, often show cores of the original rhombic pyroxene.

These aggregates are scattered, often densely, through the ground-mass, and are either colorless and brilliantly polarizing, or white and opaque, when they in turn pass into the light yellow serpentine. In thin section the serpentine is of a yellowish or light green color, of a compact amorphous nature, rarely fibrous, except in pseudo stages of alteration, and can be readily recognized by its feeble light blue color and grayish polarizing effects.

As already intimated, olivive occurs rather frequently in the serpentines, although fresh grains of the same are rare. The mineral is porphyritically developed within the serpentine groundmass, grains of which seem, as a rule, to be partly or entirely decomposed into oxide of iron. The mineral presents the usual characters. It is entirely colorless, refracts the light strongly, and gives brilliant polarizing effects, with a parallel extinction of the light. In fresher grains of the olivive, the irregular fissures which penetrate the same show along their courses the development of yellowish serpentinous matter.

But even in those serpentines where olivive is present, the serpentine seems to have originated mainly from the

tremolite, which invariably occurs disseminated as acicular aggregates through the serpentine groundmass.

Talc occurs as a secondary constituent of nearly all the serpentines; it can be recognized in the hand specimens as silvery white glistening scales. In thin section it occurs as minute leaflets, with a distinct basal separation. The extinction is parallel, and the polarization colors of a brilliant iridescent character, which serves as a means of recognizing the smallest trace.

The intimate association of characteristic minute scales of talc within masses of the tremolitic aggregates can leave little doubt but that the talc is secondary. This change is always connected with the separation of the lime in the form of calcite, granules of which are found among the products of decomposition. To get a better understanding of the serpentines it may be well to describe a typical side, taken from a light yellow, soft, earthy serpentine of the eastern end of the belt. The rock can be picked up along the road side, and contains rounded grains of chromite.

The thin section of this rock, examined with ordinary light, shows a uniform light yellow groundmass in which are embedded light colored columns of tremolite fibres, which on their borders are altering into serpentine. A few rounded grains of partly decomposed olivive lie scattered through the groundmass, together with larger particles of chromic iron ore.

Between crossed nicols the apparently homogeneous serpentine is filled with great numbers of tremolitic aggregates, which polarize with greater or less distinctness, until they merge into the faintly polarizing serpentine, which gives only pale blue or grayish colors. Many of the larger bundles of tremolite fibres show in their centers cores of the original bronzite.

Talc occurs in groups of leafy aggregates in association with the tremolite, and in one case lining a fissure extending in the longer direction of one of these tremolite columns.

The rock before us is a typical case of the common tremolite serpentine, in which olivive takes but a subordinate

part of a source of serpentine, occurring only as an accessory product.

Structural Considerations.—The structural position of these rocks presents many difficulties to the observer. Past writers have considered these and similar rocks from the structural point of view alone, calling the black massive rocks of the dioritic habit true "traps," and placing their associated schistose rocks, of like composition, within the category of the crystalline schists. This view we have found subject to certain alterations, since all the feldspathic hornblende rocks, whether perfectly massive or partly foliated, are found to be genetically one. The schistose habit which these rocks commonly develop is quite identical with similar structural changes observed in the Delaware gabbro-diorites, where pressure has been assumed as a sufficient cause for developing out of a massive mother rock a secondary product of a more or less foliated character. If the alteration of rhombic pyroxene into secondary amphibole took place as a result of a reaction between the former and certain lime-bearing minerals present, as plagioclase and green hornblende, it is possible to conceive of mechanical energy and consequent heat sufficient to make these pseudomorphic changes possible, and yet perhaps insufficient to cause even a partially plastic condition in the whole rock, or anything approaching fusion.

The serpentine, wherever it is possible to observe it in a quarry, shows a bedding structure more or less obscure. This bedding, however, in the cases observed by the author is distinctly massive, in which case the so-called bedding planes might be taken as jointage planes, and in this respect similar to certain jointage planes in the Delaware gabbros.

At any rate it would be difficult to prove that these so-called planes of bedding are any evidence whatever of a sedimentary origin, since similar planes can probably be induced by pressure. Thus there seems to be no good reason to doubt but that all the rocks of this belt can be traced back to an original pyroxenic magma, erupted through the Azoic schists which surround the belt.

DELAWARE COLLEGE, *June 29, 1887.*

LIST OF

THE PUBLICATIONS

OF THE

GEOLOGICAL SURVEY OF PENNSYLVANIA.

FROM 1874 TO 1889.

ANNUAL REPORTS.

1885 ANNUAL. J. P. Lesley, State Geologist, 8°, 769 pp., with preface and index, accompanied by Atlas 8°, 8 pl., and maps, 1886, contains the following special reports:

1. Oil and Gas. John F. Carll.
2. Vegetable Origin of Coal. Leo Lesquereux.
3. Pittsburg Coal Region. E. V. d'Invilliers.
4. Wellersburg Coal Basin. J. P. Lesley and E. B. Harden.
5. Tipton Run Coal Basin. C. A. Ashburner.
6. Anthracite Coal Region. C. A. Ashburner.
7. Wyoming Valley Fossils. C. A. Ashburnor and A. Heilprin.
8. Bernice Coal Basin. C. A. Ashburner.
9. Mehoopany Coal Field. F. A. Hill.
10. Cornwall Ore Mines. J. P. Lesley and E. V. d'Invilliers.
11. Delaware and Chester Kaolins. J. P. Lesley and C. A. Ashburner.
12. Quaternary Geology, Wyoming Valley. C. A. Ashburner, F. A. Hill, and H. C. Lewis.
13. Pressure, &c., of Rock Gas. J. P. Lesley.
14. Progress Geodetic Survey. Mansfield Merriman.

1886 ANNUAL. J. P. Lesley, State Geologist, 8°, in four parts, as follows:

i. Pittsburgh Coal Region. E. V. d'Invilliers.
ii. Oil and Gas Region. J. F. Carll, F. C. Phillips, B. S. Lyman.
iii. Anthracite Coal Region with Atlas. F. A. Hill.
iv. 1. The Lehigh River Cross Section. Arthur Winslow.
2. Paint Ores along the Lehigh River. F. A. Hill.
3. Iron Ore Mines and Limestone Quarries of the Cumberland-Lebanon Valley. E. V. d'Invilliers.
4. Geology of Radnor township, Delaware co., &c. T. D. Rand. With an Atlas.

1887 ANNUAL. J. P. Lesley, State Geologist, 8°, pp. 105, with a map of the New Boston Anthracite basin.

1. Cave Fossils. Prof. Joseph Leidy.
2. Fossil tracks in the Trias. Atreus Wanner.
3. New Boston Anthracite Basin. Benj. Smith Lyman.
4. State Line Serpentine. Prof. F. D. Chester.

MISCELLANEOUS REPORTS.

A. A history of the First Geological Survey of Pennsylvania, from 1836 to 1858, by J. P. Lesley. With the annual reports of the Board to the Legislature for 1874 and 1875. 8°, pp. 226, 1876.

B. Report on the Minerals of Pennsylvania, by F. A. Genth; and on the hydro-carbon compounds, by S. P. Sadtler. With a reference map of the State. 8°, pp. 206, 1875.

B 2. Report on the Minerals, by F. A. Genth, continued from page 207 to 238. 8°, in paper cover, pp. 31, 1876. (Bound with B.)

M. Report of Chemical Analyses in 1874–5, in the Laboratory at Harrisburg, by A. S. McCreath. 8°, pp. 105, 1875.

M 2. Report of Chemical Analyses in 1876–8, by A. S. McCreath; Classification of coals, by P. Frazer; Fire-brick tests, by F. Platt; Dolomitic limestone beds, by J. P. Lesley; Utilization of anthracite slack, by F. Platt; Dermination of Carbon in iron or steel, by A. S. McCreath. With one folded, plate (section at Harrisburg) and four page plates. 8°, pp. 438, 1879.

M 3. Report of Chemical Analyses in 1879–80, by A. S. McCreath. With a reference map of 93 iron ore mines in the Cumberland Valley. 8°, pp. 126, 1881.

N. Report on the Levels above tide of railroads, canal and turnpike stations, mountain tops, &c., in and around Pennsylvania, in 200 tables, by C. Allen. With a map. 8°, pp. 279, 1878.

O. Catalogue of specimens collected by the survey, (No. 1 to No. 4,264,) by C. E. Hall. 8°, pp. 217, 1878.

O 2. Catalogue (continued from No. 4,265 to No. 8,974); also catalogue of fossils, (pp. 231 to 239.) 8°, pp. 272, 1880.

O 3. Catalogue (continued from No. 8975 to No. 12872. Also Catalogue of special collections of fossils in stratigraphical order, from 201-1 to C 7-4-3; and Revised Catalogue of Randall's collection, from 9167 to 9625. 8°, pp. 260, 1889.

P. Report on the Coal Flora of Pennsylvania and the United States. Vols. 1 and 2, (bound together,) by L. Lesquereux. 8°, pp. 694, 1880.

P. Report on the Coal Flora of Pennsylvania and the United States Vol. 3, with 24 double page plates (lithographed) of coal plants, to accompany P., Vols. 1 and 2. 8°, pp. 283, 1884.

(P.) Atlas of 87 double page plates (lithographed) of coal plants to accompany P., Vols. 1 and 2. 8°, 1879.

P 2. Report on Permo-Carboniferous plants from W. Va. and Greene county, Pennsylvania, by W. M. Fontaine and I. C. White. With 38 double page plates (lithographed). 8°, pp. 143, 1880.

P 3. Description of *Ceratiocaridæ*, by C. E. Beecher; and of *Eurypteridæ*, by James Hall. With 8 plates. 8°, pp. 39, 1884.

P 4. Dictionary of Fossils found in Pennsylvania and elsewhere with electrotype illustrations of the various forms. In 2 volumes and an appen-

dix, by J. P. Lesley. Volume I in press. Volume II, in preparation. 8°, pp. 800±, 1889.

X. GEOLOGICAL HAND ATLAS of the sixty-seven counties of Pennsylvania, with a short explanation of the geological structure of each county, embodying the results of the field work of the survey from 1874 to 1884, by J. P. Lesley. With 62 colored maps and a cross section. 8°, pp. cxii, 1885.

Z. Report on the TERMINAL MORAINE across Pennsylvania, by H. C. Lewis; including extracts from descriptions of the Moraine in New Jersey by G. H. Cook, and in Ohio, Kentucky and Indiana, by G. F. Wright. With a map of the State, 18 photographic views of the Moraine, and 32 page plate maps and sections. 8°, pp. lvi and 299, 1884.

GRAND ATLAS, Div. I, Pt. I, 1885, port-folio containing maps of 56 counties. and parts of counties (scale 2 miles to 1 inch) on 49 sheets (26″×32″.) These maps are duplicate prints on heavy paper of the county maps contained in the reports of progress.

Annual Report, 1886. Part IV.

ANTHRACITE REGION.

A 2. Report on the causes, kinds and amount of WASTE in mining anthracite, by F. Platt; with a chapter on METHODS of mining, by J. P. Wetherill, Illustrated by 35 figures of mining operations, a plan of the Hammond breaker, and a specimen sheet of the maps of the Anthracite coal fields. 8°, pp. 134, 1881.

AC. Report on MINING METHODS, &c., in the anthracite coal fields, by H. M. Chance. Illustrated with 54 plates and 60 illustrations in the text. 8°, pp. 574, 1883. With an ATLAS containing 25 plates illustrating coal mining.

AA. First report of progress of the anthracite survey; PANTHER CREEK BASIN, by C. A. Ashburner; with a determination of the latitude and longitude of Wilkes-Barre and Pottsville, by C. L. Doolittle; and a theory of stadia measurements, by A. Winslow. 8°, pp. 407, 1883.

AA. Second report of progress of the anthracite survey, Part I; Statistics of Production and Shipment for 1883 and 1884. Charles A. Ashburner, geologist in charge.

(AA.) ATLAS OF SOUTHERN anthracite field, Part I, containing 13 sheets; 3 geological and mine sheets, 3 cross section sheets, 3 columnar section sheets, 1 topographical map sheet, and 1 coal bed area sheet, relating to the PANTHER CREEK BASIN; 1 general map of the anthracite region, and 1 chart of anthracite production from 1820 to 1881. 8°, 1882. Charles A. Ashburner, geologist in charge; A. W. Sheafer and Frank A. Hill, assistant geologists.

(AA.) ATLAS SOUTHERN anthracite field, Part II, containing 13 mine sheets between Tamaqua and Tremont. 8°, 1889. Frank A. Hill, geologist in charge; A. DW. Smith, assistant geologist. In Press.

(AA.) ATLAS SOUTHERN anthracite field, Part III, containing 12 mine sheets between Tremont and the western end of the southern basin, and a general map of the anthracite fields showing the location of collieries. 8°, 1889. Frank A. Hill, geologist in charge; A. DW. Smith, assistant geologist. In Press.

(AA.) ATLAS SOUTHERN anthracite field, Part IV. In Press.

(AA.) ATLAS OF WESTERN MIDDLE anthracite field, Part I, containing 11 sheets; 4 geological and mine sheets between Delano and Locust Dale, 3

topographical sheets between Quakake Junction and Mount Carmel, and 4 cross section sheets. 8°, 1884. Charles A. Ashburner geologist in charge; A. W. Sheafer and Bard Wells, assistant geologists.

(**AA.**) ATLAS OF WESTERN MIDDLE anthracite field, Part II, containing 11 sheets; 4 geological and mine sheets from Mount Carmel to the western end of the coal field, and 7 columnar section sheets covering the entire field. 8°, 1887. Frank A. Hill, geologist in charge; Bard Wells, assistant geologist.

(**AA.**) ATLAS OF WESTERN MIDDLE anthracite field. Part III. In Press.

(**AA.**) ATLAS OF NORTHERN anthracite field, Part I, containing 6 geological and mine sheets between Wilkes-Barre and Nanticoke, 3 cross section sheets and 4 columnar section sheets. 8°, 1885. Charles A. Ashburner, geologist in charge; Frank A. Hill, assistant geologist.

(**AA.**) ATLAS OF NORTHERN anthracite field, Part II, containing 10 sheets; 4 mine sheets relating to that portion of the Wyoming-Lackawanna coal basin between Wyoming and Taylorville, and 2 topographical and mine sheets relating to the extreme western end of the Wyoming basin; 4 columnar section sheets of bore-holes, shafts and tunnels. 8°, 1887. Frank A. Hill, geologist in charge; William Griffith, assistant geologist.

(**AA.**) ATLAS OF NORTHERN anthracite field, Part III, containing 8 sheets; 4 mine, and 4 columnar section sheets relating to that portion of the Lackawanna basin in the vicinity of Taylorville, Minooka, Scranton, Dunmore and Priceville. 8°, 1889. Frank A. Hill, geologist in charge; William Griffith, assistant geologist.

(**AA.**) ATLAS OF NORTHERN anthracite field, Part IV, containing 8 mine sheets relating to that portion of the Lackawanna basin in the vicinity of Olyphant, Peckville, Jessup, Winton, Archbald, Jermyn, Glenwood, Carbondale, and Forest City in Lackawanna and Susquehanna counties. 8°, 1889. Frank A. Hill, geologist in charge; William Griffith, assistant geologist.

(**AA.**) ATLAS OF NORTHERN anthracite field, Part V. In Press.

(**AA.**) ATLAS EASTERN MIDDLE anthracite field, Part I, containing 8 sheets, 2 geological and mine sheets in the vicinity of Hazleton, Drifton and surrounding towns, 3 cross section sheets and 3 columnar section sheets. 8°, 1885. Charles A. Ashburner, geologist in charge; A. P. Berlin and Arthur Winslow, assistant geologists.

(**AA.**) ATLAS OF EASTERN MIDDLE anthracite field, Part II, containing 8 sheets; 6 mine, and 2 columnar section sheets relating to portions of the Lehigh basins in the vicinity of Upper Lehigh, Pond Creek, Sandy Run, Eckley, Weatherly, Buck Mountain, Beaver Meadow, Coleraine, Jeansville and Audenried, in Luzerne, Carbon, and Schuylkill counties. 8°, 1888. Frank A. Hill, geologist in charge; I. R. Moister, assistant geologist.

(**AA.**) ATLAS EASTERN MIDDLE anthracite field, Part III, containing 13 sheets, 8 mine sheets, covering the entire western part of the field, 2 columnar section sheets and 3 cross section sheets. 8°, 1889. Frank A. Hill, geologist in charge; I. R. Moister, assistant geologist.

GRAND ATLAS, Div. II, Pt. I, 1884. Port-folio containing 26 sheets, (26″×32″), as follows: 13 sheets Atlas Southern Anthracite Field, Part I, 11 sheets Atlas Western Middle Anthracite Field, Part I, 1 sheet photo views of plaster models in Western, Middle and Southern Fields, and 1 specimen sheet, Report A 2.

GRAND ATLAS, Div. II, Pt. II, 1885. Port-folio containing 22 sheets, (26″×32″), as follows: 13 sheets Atlas Northern Anthracite Field, Part I, 8 sheets Atlas Eastern Middle Anthracite Field, Part I, and one sheet containing a preliminary general map of the Anthracite Coal Fields and adjoining counties.

For Anthracite coal in SULLIVAN county, see G 2 and Annual Report, 1885.

For Conglomerate beds near Carbondale, Pittston, &c., see G 5, G 7.

For Utilization of anthracite slack, see M 2.

For General description anthracite region, Quaternary Geology of the Wyoming-Lackawanna Valley, &c., &c., see Annual Report, 1885.

Annual Report, 1886. Part III.

BITUMINOUS COAL FIELDS AND SURROUNDING AREAS.

H. First report on CLEARFIELD and JEFFERSON counties, by F. Platt. With 8 maps, 2 sections and 139 cuts in the text. 8°, pp. 296, 1875. (*For second report, see H 6, H 7.*)

H 2. Report on CAMBRIA county, by F. & W. G. Platt. With 4 maps and sections and 84 cuts in the text. 8°, pp. 194, 1877.

H 3. Report on SOMERSET county, by F. & W. G. Platt. With 6 maps and sections and 110 cuts in the text. 8°, pp. 348, 1877.

Atlas to Reports H^2 and H^3 containing geological maps of Cambria and Somerset counties, with 2 sheets of columnar sections and 1 cross section ; a revision and correction of the semi-bituminous coal section at Wellersburg, Somerset county, and notes on the new mines in Cambria county. 8°, 1889.

H4. Report on INDIANA county, by W. G. Platt. With a colored geological county map and 87 cuts in the text. 8°, pp. 316, 1878.

H 5. Report on ARMSTRONG county, by W. G. Platt. With a colored geological county map and 58 cuts in the text. 8°, pp. 338, 1880.

H 6. Second report on JEFFERSON county, (*See H above*), by W. G. Platt. With a colored geological county map and 57 cuts in the text. 8°, pp. 218, 1881.

H 7. Second report on CLEARFIELD county, (*See H above*), by H. M. Chance. With a colored geological county map, an outcrop map of the Houtzdale basin and 58 cuts in the text. 8°, pp. 197, 1884.

I. Report on VENANGO county, by J. F. Carll. The geology around Warren, by F. A. Randall. Notes on the comparative geology of N. E. Ohio, N. W. Pa., and W. New York, by J. P. Lesley. With one small map of the Venango oil region, one small map of the region south and east of Lake Erie, one long section of the rocks at Warren, and 7 cuts in the text. 8°, pp. 127, 1875.

I 2. Report of oil well records and levels in VENANGO, WARREN, CRAWFORD, CLARION, ARMSTRONG, BUTLER, &c., by J. F. CARLL. 8°, pp. 398, 1877.

I 3. Report on the VENANGO, WARREN, CLARION, and BUTLER OIL REGIONS ; descriptions of rig, tools, &c.; survey of the Garland and Panama conglomerates, &c.; discussion of pre-glacial and post-glacial drainage, by J. F. Carll. With 23 page plates and an atlas. 8°, pp. 482, 1880.

(**I 3.**) Atlas of 22 sheets. Map of Venango county, colored geologically ; map of lower oil field (Butler, Armstrong, and Clarion) in two sheets; 3 local contour maps at Franklin, Titusville and Spring Creek ; two maps of N. W. Pennsylvania, showing the past and present drainage ; long section across W. Pennsylvania; vertical section of the formations from the Upper

Coal measures down to the bottom of the Devonian; diagram map and section of Third sand; profile section from Meadville, S. W.; 5 sheets of grouped oil well sections; 5 sheets of working drawings for well boring, &c.; diagram of daily rate of drilling six wells at Petrolia.

I 4. Report on WARREN county, by J. F. Carll. With a colored geological county map, a map of the Warren oil region, and 2 sheets of oil well sections. 8°, pp. 439, 1883. (*Note—The first 147 pages of this book contain oil well records; see under Petroleum Fields below.*)

J. Report on the OIL REGION, by H. E. Wrigley; map and profile of line of levels through Butler, Armstrong, and Clarion, by D. J. Lucas; map and profile of Slippery Rock creek, by J. P. Lesley. 5 maps and sections, a plate and 5 cuts. 8°, pp. 122, 1875.

K. Report on GREENE and WASHINGTON counties, by J. J. Stevenson. With two county maps. (Showing the calculated local depths of the Pittsburgh and Waynesburg coal beds beneath the surface,) and 3 page plates of general sections. 8°, pp. 419, 1876. (*Note.—Since the publication of this book two colored geological county Maps have been published, and will be found in pocket of volume K 3 described below.*)

K 2. First report on FAYETTE, WESTMORELAND and S. E. ALLEGHENY counties, (*i. e.*, west of Chestnut Ridge,) by J. J. Stevenson. With 3 colored geological county maps and 50 cuts in the text. 8°, pp. 437, 1877.

K 3. Second report on FAYETTE and WESTMORELAND counties (the Ligonier Valley), by J. J. Stevenson. With 4 page plates and 107 cuts in text 8°, pp. 331, 1878. (*Note.—In a pocket in this volume will be found the colored geological maps of Greene and Washington counties alluded to above.*)

K 4. Report on MONONGAHELA RIVER COAL MINES, from the West Virginia State Line to Pittsburgh, (including some on the Youghiogheny and other streams), by J. Sutton Wall. With a map of the region in a pocket, 12 heliotype pictures, and 26 page plates. 8°, pp. 231, 1884.

L. Report on the YOUGHIOGHENY coke manufacture, by F. Platt; Notes on the coal and iron ore beds, by C. A. Young; Report on methods of coking by J. Fulton, (*See G* below); Report on the use of natural gas in the iron manufacture, by J. B. Pearse and F. Platt; The Boyd's Hill gas well at Pittsburgh, by J. P. Lesley. With a map of the coke region, two folded plates of coke ovens, and page plates and cuts in the text. 8°, pp. 252, 1876.

Q. Report on BEAVER, N. W. ALLEGHENY and S. BUTLER counties by I. C. White. With 3 colored geological county maps, and 21 page plates of sections. 8°, pp. 337, 1878.

Q 2. Report on LAWRENCE county, and special Report on Correlation of the Pennsylvania and Ohio coal beds, by I. C. White. With a colored geological county map and 134 cuts in the text. 8°, pp. 336, 1879.

Q 3. Report on MERCER county, by I. C. White. With a colored geological county map and 119 cuts in the text. 8°, pp. 233, 1880.

Q 4. Report on CRAWFORD and ERIE counties, by I. C. White. With two colored geological county maps and 107 cuts in the text. Also, a Report on a pre-glacial outlet for Lake Erie, by J. W. Spencer. With two maps of the Lake region. 8°, pp. 406, 1881.

R. Report on McKEAN county, and its geological connections with Cameron, Elk, and Forest counties, by C. A. Ashburner. With 33 page plates of vertical and columnar sections, pictures of Rock city and Olean conglomerate, Wilcox and Kane spouting wells, map of Howard Hill coal field, &c., and an atlas of 8 sheets. 8°, pp. 371, 1880.

(**R.**) Atlas for McKean county of 8 sheets :—Colored geological county map; three topographical maps; of Buffalo Coal Company tract, Alton coal basin, and Potato Creek coal basin: map of McKean oil district; one sheet of columnar sections between Bradford and Ridgway; and 2 diagram sheets of the Well account and Production account in the Bradford district.

R 2. Part II, report on township geology of Cameron, Elk and Forest counties, by C. A. Ashburner.

(**R 2.**) Atlas for Cameron, Elk and Forest counties, of 11 sheets (*Published November, 1884, in advance of the report*) :—3 colored geological county maps; 1 anticlinal and synclinal map; 1 topographical map McKean county; 2 tract maps Forest and Elk counties; 1 map Straight Creek coal basin; 2 sheets oil well sections; and 1 sheet coal sections.

V. Report on N. Butler county; and (Part 2) special report on the Beaver and Shenango river coal measures, by H. M. Chance. With a colored geological map of N. Butler; a contour local map around Parker; a map of the anticlinal rolls in the 6th basin; a chart of the Beaver and Shenango rivers; profile section from Homewood to Sharon; Oil well records and surface sections; and 154 cuts in the text. 8°, pp. 248, 1879.

V 2. Report on Clarion county, by H. M. Chance. With a colored geological county map, a map of the anticlinals and oil-belt; a contoured map of the old river channel at Parker; 4 page plates, and 83 cuts in the text. 8°, pp. 232, 1880.

For the coal basins of Bradford and Tioga counties, see report G.

For the coal basins of Lycoming and Sullivan, see report G 2.

For the coal basins of Potter county, see G 3.

For the coal basins of Clinton county, see G 4.

For the coal in Wayne county see G 5, and Northern Atlas, Part IV.

For the East Broad Top coal basin in Huntingdon county, see F.

For the mountain coals in Blair county, see T.

For the Broad Top coal measures in Bedford and Fulton counties, see T 2.

For the coal basins in Centre county, see T 4.

For coal analyses, see M, M 2, M 3.

For classification of coals, see in M 2.

For coal plants, see P, P 2.

For fossil crustaceans in coal slate, see P 3.

For Origin of Coal; Pittsburgh Region and Monongahela Valley; Wellersburg coal basin, Somerset county; and Tipton Run coal-beds, Blair county; see Annual Report, 1885, and Atlas H 2 and H 3.

Grand Atlas Div. III, Pt. I, 1885, port-folio containing 35 sheets (26″×32″) as follows: 32 sheets relating to portions of the Petroleum and Bituminous Coal Fields, and three sheets relating to the Quaternary period.

Annual Report, 1886. Part I.

PETROLEUM AND GAS.

See reports I, I 2, I 3, I 4, and J, under Bituminous Coal Fields.

See L, for the Pittsburgh gas well, and the use of gas in the iron manufacture.

See Q, Q 2, Q 3, Q 4, for references to oil rocks in Beaver, Lawrence, Mercer, Crawford, Erie, and S. Butler counties.

See K for the Dunkard Creek oil wells of Greene county.

See R, R 2, for descriptions of oil rocks in McKean, Elk, and Forest counties.

See V, V 2, for notes on the oil rocks of N. Butler and Clarion counties.

See H 2 for oil boring at Cherry Tree, Cambria county.

See G 5 for oil boring in Wayne county.

See Annual Report, 1885, for report of progress in the oil and gas region with special facts relating to the geology and physics of natural gas.

See Grand Atlas, Div. III, Pt. I, under Bituminous Coal Fields.

See Annual Report, 1886. Part II.

NORTH-EASTERN AND MIDDLE PENNSYLVANIA.

(Palæozoic formations from the Coal Measures down.)

D. First report on LEHIGH county iron mines, by F. Prime. With a contour line map of the ore region and 8 page plates. 8°, pp. 73, 1875.

D 2. Second report on LEHIGH county iron mines, by F. Prime. With a colored geological contour line map of the iron region, (in 4 sheets,) a colored geological contour line map of the Ironton mines, 4 double page lithograph pictures of Limestone quarries, and one page plate of *Monoeraterion.* 8°, pp. 99, 1878.

D 3. Vol. I. Report on LEHIGH and NORTHAMPTON counties. Introduction by J. P. Lesley ; Slate belt, by R. H. Sanders ; Limestone belt and iron mines, by F. Prime ; South mountain rocks, by F. Prime and C. E. Hall. With 3 lithograph pictures of quarries, 4 pictures of triangulation stations, 14 page plates of sections, and an atlas of maps. 8°, pp. 283, 1883. *(Note.—For atlas see below.)*

D 3. Vol. II, Part I. Report on BERKS county, *(South mountain belt)* by E. V. d'Invilliers. With 10 page plates of sections and Indian relics, and 3 pictures of rock exposures. 8°, pp. 441, 1883. *(Note.—For atlas see below.*

(D 3.) ATLAS : One colored geological map of *Lehigh* and Northampton counties, *(one sheet ;)* one colored geological contour line map of southern Northampton county, *(six sheets ;)* a contour line map of the mountains from the Delaware to the Schuylkill, *(eighteen sheets ;)* a colored geological contour line index map to the 22 sheets, *(one sheet ;)* and 4 sheets of maps of iron mines.

(D 5.) ATLAS of colored geological county maps of CUMBERLAND, FRANKLIN, and ADAMS, *(three sheets ;)* and first instalment of contour line map of the South mountains, Sheets A 1, A 2, B 1, B 2, *(four sheets ;)* by A. E. Lehman.

F. Report on the JUNIATA RIVER district in MIFFLIN, SNYDER, and HUNTINGDON counties, by J. H. Dewees, and on the Aughwick valley and East Broad Top region in HUNTINGDON county, by C. A. Ashburner. With colored geological maps of East Broad Top R. R. and Orbisonia vicinity, (2 sheets ;) Three Springs map and section, (2 sheets ;) Sideling Hill Creek map and section, (2 sheets,) and Isometric projection at Three Springs, (1 sheet ;) six folded cross sections and 22 page plates of local maps and columnar sections. 8°, pp. 305, 1878.

F 2. Report on PERRY county, *(Part 1, geology,)* by E. W. Claypole. With two colored geological maps of the county ; 17 geological outline township maps as page plates, and 30 page plate cross and columnar sections. 8°, pp. 437, 1884.

G. Report on BRADFORD and TIOGA counties, by A Sherwood ; report on their coal fields, (including forks of Pine creek in Potter county,) by F. Platt ; report on the COKING of bituminous coal, by J. Fulton. *(See L above.)* With

two colored geological county maps, 3 page plates, and 35 cuts in the text. 8°, pp. 271, 1878.

G 2. Report on LYCOMING and SULLIVAN counties; field notes by A. Sherwood; coal basins by F. Platt. With two colored geological county maps (of Lycoming and Sullivan,) a topographical map (in two sheets) of the Little Pine creek coal basin, and 24 page plates of columnar sections. 8°, pp. 268, 1880.

G 3. Report on POTTER county, by A. Sherwood. Report on its COAL FIELDS, by F. Platt. With a colored geological county map, 2 folded plates and 2 page plates of sections. 8°, pp. 121, 1880.

G 4. Report on CLINTON county, by H. M. Chance, including a description of the Renovo coal basin, by C. A. Ashburner, and notes on the Tangascootac coal basin, by F. Platt. With a colored geological county map, 1 sheet of sections, local Renovo map, 6 page plates, and 21 sections in the text. 8°, pp. 183, 1880.

G 5. Report on SUSQUEHANNA and WAYNE counties by I. C. White. With a colored geological map of the two counties and 58 cuts in the text. 8°, pp. 243, 1881.

G 6. Report on PIKE and MONROE counties, by I. C. White. With two colored geological county maps, (1 sheet Pike and Monroe and 1 sheet Wyoming), a map of glacial scratches, and 7 small sections. Report on the Delaware and Lehigh Water Gaps, with two contoured maps and five sections of the gaps, by H. M. Chance. 8°, pp. 407, 1882.

G 7. Report on WYOMING, LACKAWANNA, LUZERNE, COLUMBIA, MONTOUR and NORTHUMBERLAND counties, (*i. e.*, the parts lying *outside* of the anthracite coal fields), by I. C. White. With a colored geological map of these counties (in two sheets), and 31 page plates in the text. 8°, pp. 464, 1883. (*Note.—The colored geological map of* WYOMING *county is published in G 6.*

T. Report on BLAIR county, by F. Platt. With 35 cuts in the text and an Atlas of maps and sections (see below). 8°, pp. 311, 1881.

(T.) Atlas of colored geological contour line map of Morrison's cove, Canoe valley, Sinking valley and country west to the Cambria county line (14 sheets); Index map of the same (1 sheet); colored sections (2 sheets). 8°, 1881.

T 2. Report on BEDFORD and FULTON counties, by J. J. Stevenson. With two colored geological maps of the two counties. 8°, pp. 382, 1882.

T 3. Report on HUNTINGDON county, by I. C. White. With a colored geological map of the county, and numerous sections. 8°, pp. 471, 1885.

T 4. Report on CENTRE county, by E. V. d'Invilliers; also special report, by A. L. Ewing, and extracts from report to Lyon, Shorb & Co., by J. P. Lesley. With a colored geological map of the county, 13 page plates of local maps and sections, and 15 cuts in the text. 8°, pp. 464, 1884.

For report on line of the Terminal Moraine, see Z.

GRAND ATLAS, Div. IV, Pt. I, 1885. Port-folio containing 43 sheets, as follows: 30 sheets relating to the Durham and Reading Hills and bordering valleys in Northampton, Lehigh, Bucks and Berks counties, and 13 sheets relating to the South Mountains in Adams, Franklin, Cumberland and York counties.

GRAND ATLAS, Div. V, Pt. I, 1885. Port-folio containing 35 sheets, as follows: 29 sheets relating to the Topography and Geology of the Palæozoic strata in parts of Cambria, Blair, Bedford, Huntingdon, Mifflin, Centre and Union counties, 5 sheets contain a map and geological cross section along

the east bank of the Susquehanna river, Lancaster county, and 1 sheet contains cross sections of the Philadelphia belt of the Azoic rocks.

For report on Cornwall Iron Ore Mines, Lebanon county, and the Tipton Run coal beds, Blair county, see Annual Report, 1885.

For report on the Iron Ore Mines and Limestone Quarries of the Cumberland-Lebanon Valley, and Paint-ore along the Lehigh river, see Annual, 1886, Part IV.

SOUTH-EASTERN PENNSYLVANIA.

C. Report on YORK and ADAMS counties, by P. Frazer. With one folded map of a belt of York county through York and Hanover, 6 folded cross sections, and two page plate microscopic slices of dolerite. 8°, pp. 198, 1876.

(Note.—The colored geological county map of YORK *is published in the* ATLAS *to C 3).*

C 2. Report on YORK and ADAMS counties, (South Mountain rocks, iron ores, &c.), by P. Frazer. With one general map of the district, 10 folded cross sections, and 5 page plates. 8°, pp. 400, 1877. *(Note.—The colored geological county map of* ADAMS *is published in D 5).*

C 3. Report on LANCASTER county, by P. Frazer. With nine double page lithographic views of slate quarries and Indian-pictured rocks, one plate of impressions on slate, and one page plate microscopic section of trap, and an atlas. 8°, pp. 350, 1880.

(C 3.) ATLAS of 13 sheets: Colored geological map of York county; colored geological map of LANCASTER county; Susquehanna river section. (Sheets 1, 1A, 2, 2A, 3, 4); Lancaster section; Pequea section; Muddy run section; Chestnut Hill mines; Gap Nickel mine.

C 4. Report on CHESTER county; General description, pp. 214, by J. P. Lesley; Field notes in the townships, pp. 215–354, by P. Frazer. With a colored geological county map, a photographic view of contorted schists and 12 page plates. 8°, pp. 394, 1883.

C 5. Report on DELAWARE county, by C. E. Hall. With a colored geological county map; 30 photographic page plate views of granite quarries, kaolin pits, &c., and 4 page plates of altered mica. 8°, pp. 128, 1885. See Annual Report, 1885, for Kaolin report.

C 6. Report on PHILADELPHIA and the southern parts of MONTGOMERY and BUCKS counties, by C. E. Hall. With a colored geological map of the belt of country between Trenton and Delaware county (in 3 sheets), a sheet of colored cross sections and 24 cuts in the text. 8°, pp. 145, 1882.

(C 7.) ATLAS to report on Bucks and Montgomery counties, containing 12 sheets of topographical map of the Neshaminy, Tohickon and Perkiomen water basins by the Philadelphia Water Department on a scale of 1,600 feet to 1 inch, $\frac{1}{19600}$ of nature. 8°, 1887.—(Report C. 7. not ready for publication.)

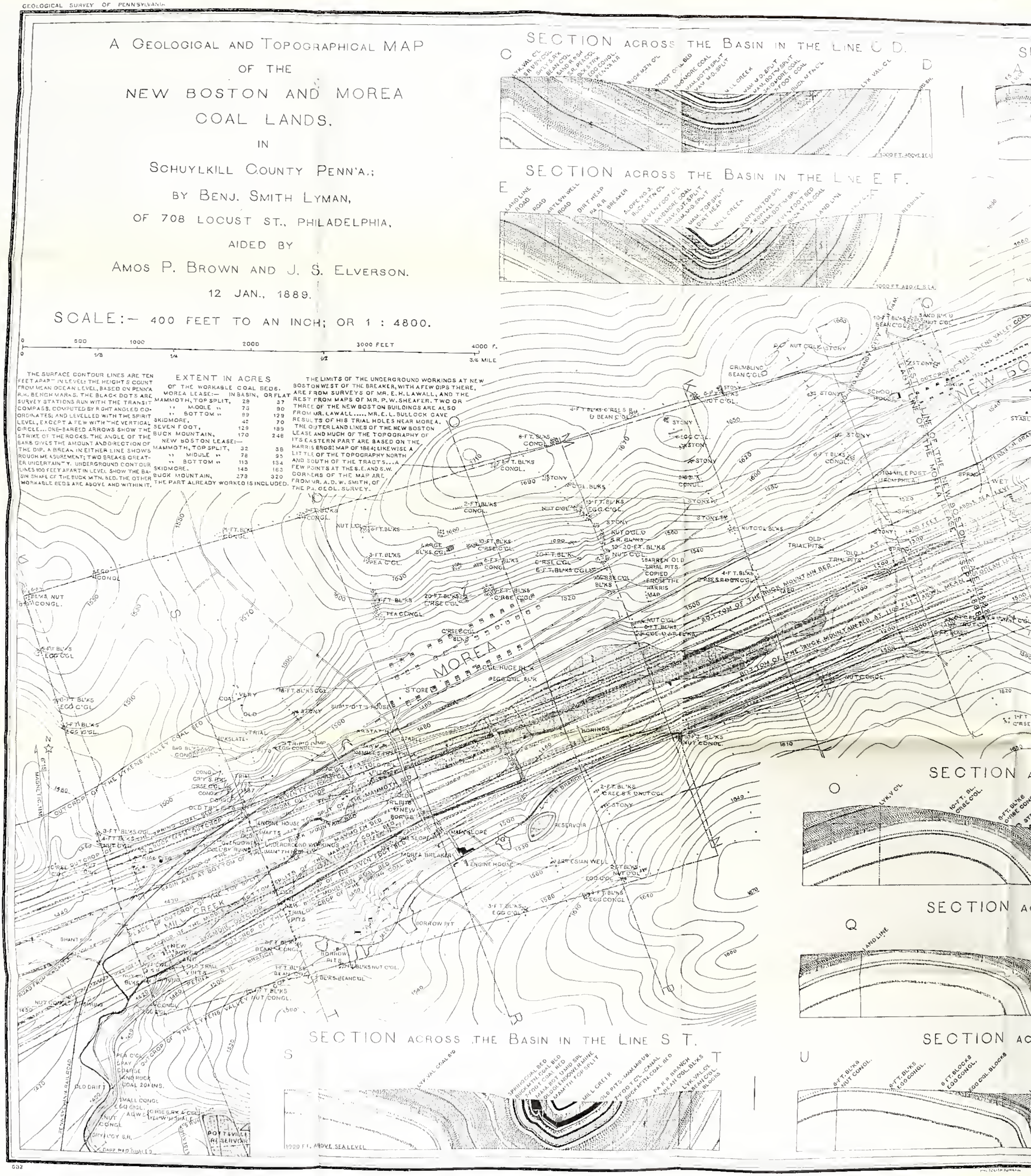
E. Part I of (historical introduction to) a report on the AZOIC rocks, by T. S. Hunt. 8°, pp. 253, 1878.

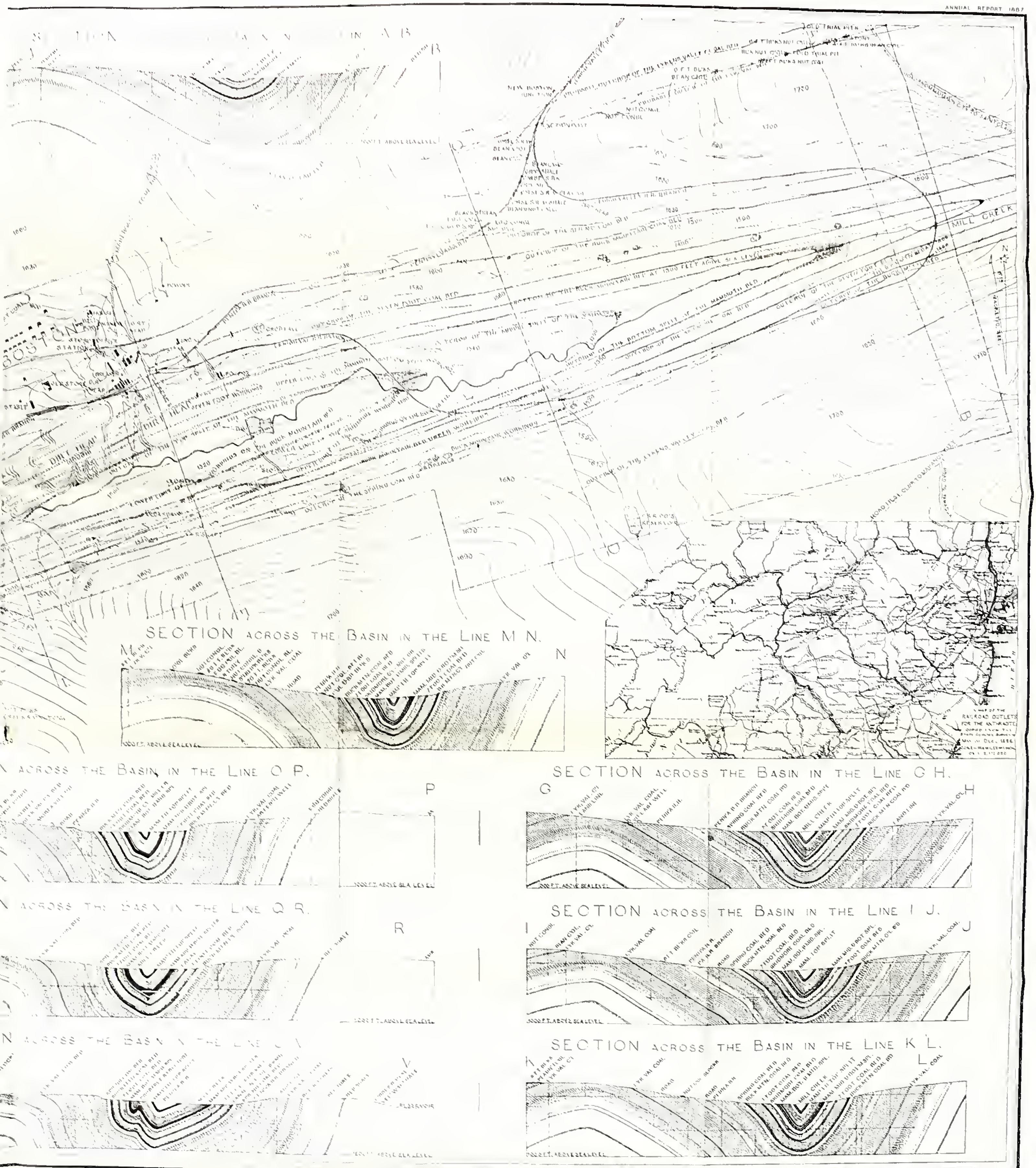
For report on the kaolin deposits of CHESTER and DELAWARE counties, see Annual Report, 1885.

For report on the Serpentines of Radnor township, Delaware Co., &c., see Annual, 1886, Part IV.

See also GRAND ATLAS, Div. V., Pt. I, under North-eastern and Middle Pennsylvania.

July 1, 1889.


A GEOLOGICAL AND TOPOGRAPHICAL MAP
OF THE
NEW BOSTON AND MOREA
COAL LANDS.
IN
SCHUYLKILL COUNTY PENN'A.;
BY BENJ. SMITH LYMAN,
OF 708 LOCUST ST., PHILADELPHIA,
AIDED BY
AMOS P. BROWN AND J. S. ELVERSON.
12 JAN., 1889.
SCALE:— 400 FEET TO AN INCH; OR 1 : 4800.
0 500 1000 2000 3000 FEET 4000 F.
0 1/8 1/4 1/2 3/4 MILE
THE SURFACE CONTOUR LINES ARE TEN FEET APART IN LEVEL: THE HEIGHTS COUNT FROM MEAN OCEAN LEVEL, BASED ON PENN'A R.R. BENCH MARKS. THE BLACK DOTS ARE SURVEY STATIONS RUN WITH THE TRANSIT COMPASS, COMPUTED BY RIGHT ANGLED CO-ORDINATES; AND LEVELLED WITH THE SPIRIT LEVEL, EXCEPT A FEW WITH THE VERTICAL CIRCLE.... ONE-BARBED ARROWS SHOW THE STRIKE OF THE ROCKS. THE ANGLE OF THE BARB GIVES THE AMOUNT AND DIRECTION OF THE DIP. A BREAK IN EITHER LINE SHOWS ROUGH MEASUREMENT; TWO BREAKS GREATER UNCERTAINTY. UNDERGROUND CONTOUR LINES 100 FEET APART IN LEVEL SHOW THE BASIN SHAPE OF THE BUCK MTN. BED. THE OTHER WORKABLE BEDS ARE ABOVE AND WITHIN IT.
EXTENT IN ACRES
OF THE WORKABLE COAL BEDS.
MOREA LEASE:— IN BASIN, OR FLAT
MAMMOTH, TOP SPLIT, 29 37
" MIDDLE " 73 90
" BOTTOM " 89 129
SKIDMORE, 42 70
SEVEN FOOT, 129 189
BUCK MOUNTAIN, 170 248
NEW BOSTON LEASE:—
MAMMOTH, TOP SPLIT, 32 38
" MIDDLE " 78 95
" BOTTOM " 113 134
SKIDMORE. 145 163
BUCK MOUNTAIN, 273 320
THE PART ALREADY WORKED IS INCLUDED.
THE LIMITS OF THE UNDERGROUND WORKINGS AT NEW BOSTON WEST OF THE BREAKER, WITH A FEW DIPS THERE, ARE FROM SURVEYS OF MR. E. H. LAWALL, AND THE REST FROM MAPS OF MR. P. W. SHEAFER. TWO OR THREE OF THE NEW BOSTON BUILDINGS ARE ALSO FROM MR. LAWALL..... MR. E. L. BULLOCK GAVE RESULTS OF HIS TRIAL HOLES NEAR MOREA. THE OUTER LAND LINES OF THE NEW BOSTON LEASE AND MUCH OF THE TOPOGRAPHY OF ITS EASTERN PART ARE BASED ON THE HARRIS BROS.' MAP OF 1864; LIKEWISE A LITTLE OF THE TOPOGRAPHY NORTH AND SOUTH OF THE TRACTS... A FEW POINTS AT THE S.E. AND S.W. CORNERS OF THE MAP ARE FROM MR. A. D. W. SMITH, OF THE PA. GEOL. SURVEY.
SECTION ACROSS THE BASIN IN THE LINE C D.
SECTION ACROSS THE BASIN IN THE LINE E F.
SECTION ACROSS THE BASIN IN THE LINE S T.
MOREA
NEW BOSTON
OUTCROP OF THE LYKENS VALLEY COAL BED
BOTTOM OF THE BUCK MOUNTAIN BED
MOREA BREAKER
RESERVOIR
MILL CREEK
STORE
BORINGS
ENGINE HOUSE
ARTESIAN WELL
BORROW PIT


BOSTON
STATION
MILL CREEK
SECTION across the Basin in the Line M N.
M
N
1000 FT. ABOVE SEA LEVEL
across the Basin in the Line O P.
P
SECTION across the Basin in the Line G H.
G
H
across the Basin in the Line Q R.
R
SECTION across the Basin in the Line I J.
I
J
SECTION across the Basin in the Line K L.
L
MAP OF THE RAILROAD OUTLETS FOR THE ANTHRACITE